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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 613

GUIDEBOOK
OF THE
WESTERN UNITED STATES

PART C. THE SANTA FE ROUTE

WITH A SIDE TRIP TO THE GRAND CANYON
OF THE COLORADO

BY

N. H. DARTON AND OTHERS

WASHINGTON
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MISSOURI BOTANICAL
GARDEN LIBRARY

PRINCIPAL DIVISIONS OF GEOLOGIC TIME.[a]

[A glossary of geologic terms is given on pp. 182-185.]

Era.	Period.	Epoch.	Characteristic life.	Duration, according to various estimates.
				Millions of years.
Cenozoic (recent life).	Quaternary.	Recent. Pleistocene (Great Ice Age).	"Age of man." Animals and plants of modern types.	1 to 5.
	Tertiary.	Pliocene. Miocene. Oligocene. Eocene.	"Age of mammals." Possible first appearance of man. Rise and development of highest orders of plants.	
Mesozoic (intermediate life).	Cretaceous.	(b)	"Age of reptiles." Rise and culmination of huge land reptiles (dinosaurs), of shellfish with complexly partitioned coiled shells (ammonites), and of great flying reptiles. First appearance (in Jurassic) of birds and mammals; of cycads, an order of palmlike plants (in Triassic); and of angiospermous plants, among which are palms and hardwood trees (in Cretaceous).	4 to 10.
	Jurassic.	(b)		
	Triassic.	(b)		
Paleozoic (old life).	Carboniferous.	Permian.	"Age of amphibians." Dominance of club mosses (lycopods) and plants of horsetail and fern types. Primitive flowering plants and earliest cone-bearing trees. Beginnings of backboned land animals (land vertebrates). Insects. Animals with nautilus-like coiled shells (ammonites) and sharks abundant.	17 to 25.
		Pennsylvanian.		
		Mississippian.		
	Devonian.	(b)	"Age of fishes." Shellfish (mollusks) also abundant. Rise of amphibians and land plants.	
	Silurian.	(b)	Shell-forming sea animals dominant, especially those related to the nautilus (cephalopods). Rise and culmination of the marine animals sometimes known as sea lilies (crinoids) and of giant scorpion-like crustaceans (eurypterids). Rise of fishes and of reef-building corals.	
	Ordovician.	(b)	Shell-forming sea animals, especially cephalopods and mollusk-like brachiopods, abundant. Culmination of the buglike marine crustaceans known as trilobites. First trace of insect life.	
	Cambrian.	(b)	Trilobites and brachiopods most characteristic animals. Seaweeds (algæ) abundant. No trace of land animals found.	
Proterozoic (primordial life).	Algonkian.	(b)	First life that has left distinct record. Crustaceans, brachiopods, and seaweeds.	
	Archean.	Crystalline rocks.	No fossils found.	50 +

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[a] The geologic record consists mainly of sedimentary beds—beds deposited in water. Over large areas long periods of uplift and erosion intervened between periods of deposition. Every such interruption in deposition in any area produces there what geologists term an unconformity. Many of the time divisions shown above are separated by such unconformities—that is, the dividing lines in the table represent local or widespread uplifts or depressions of the earth's surface.

[b] Epoch names omitted; in less common use than those given.

PREFACE.

By George Otis Smith.

The United States of America comprise an area so vast in extent and so diverse in natural features as well as in characters due to human agency that the American citizen who knows thoroughly his own country must have traveled widely and observed wisely. To "know America first" is a patriotic obligation, but to meet this obligation the railroad traveler needs to have his eyes directed toward the more important or essential things within his field of vision and then to have much that he sees explained by what is unseen in the swift passage of the train. Indeed, many things that attract his attention are inexplicable except as the story of the past is available to enable him to interpret the present. Herein lie the value and the charm of history, whether human or geologic.

The present stimulus given to travel in the home country will encourage many thousands of Americans to study geography at first hand. To make this study most profitable the traveler needs a handbook that will answer the questions that come to his mind so readily along the way. Furthermore, the aim of such a guide should be to stimulate the eye in the selection of the essentials in the scene that so rapidly unfolds itself in the crossing of the continent. In recognition of the opportunity afforded in 1915 to render service of this kind to an unusually large number of American citizens, as well as to visitors from other countries, the United States Geological Survey has prepared a series of guidebooks[1] covering four of the older railroad routes west of the Mississippi.

These books are educational in purpose, but the method adopted is to entertain the traveler by making more interesting what he sees from the car window. The plan of the series is to present authoritative information that may enable the reader to realize adequately the scenic and material resources of the region he is traversing, to comprehend correctly the basis of its development, and above all to appreciate keenly the real value of the country he looks out upon, not as so many square miles of territory represented on the map in a railroad folder by meaningless spaces, but rather as land—real estate, if you please—varying widely in present appearance because differing largely in its history and characterized by even greater variation in values because possessing diversified natural resources. One region may be such as to afford a livelihood for only a pastoral people; another may present opportunity for intensive agriculture; still another may contain hidden stores of mineral wealth that may attract large industrial development; and taken together these varied resources afford the promise of long-continued prosperity for this or that State.

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[1] Guidebook of the western United States: Part A, The Northern Pacific Route, with a side trip to Yellowstone Park (Bulletin 611); Part B, The Overland Route, with a side trip to Yellowstone Park (Bulletin 612); Part C, The Santa Fe Route, with a side trip to Grand Canyon of the Colorado (Bulletin 613); Part D, The Shasta Route and Coast Line (Bulletin 614).

Items of interest in civic development or references to significant epochs in the record of discovery and settlement may be interspersed with explanations of mountain and valley or statements of geologic history. In a broad way, the story of the West is a unit, and every chapter should be told in order to meet fully the needs of the tourist who aims to understand all that he sees. To such a traveler-reader this series of guidebooks is addressed.

To this interpretation of our own country the United States Geological Survey brings the accumulated data of decades of pioneering investigation, and the present contribution is only one type of return to the public which has supported this scientific work under the Federal Government.

In preparing the description of the country traversed by the Santa Fe Route the geographic and geologic information already published as well as unpublished material in the possession of the Geological Survey has been utilized, but to supplement this material Mr. Darton made a field examination of the entire route in 1914. Information has been furnished by Erasmus Haworth, J. E. Todd, and R. T. Hill, as well as by others whose writings are listed in the bibliography at the end of the text. Cooperation has been rendered by the United States Reclamation Service and by bureaus of the Department of Agriculture. Railroad officials and other citizens have also generously given their aid, and other members of the Survey have freely cooperated in the work.

For the purpose of furnishing the traveler with a graphic presentation of each part of his route, the accompanying maps, 25 sheets in all, have been prepared, with a degree of accuracy probably never before attained in a guidebook, and their arrangement has been planned to meet the convenience of the reader. The special topographic surveys necessary to complete these maps of the route were made by W. O. Tufts.

GUIDEBOOK OF THE WESTERN UNITED STATES.

PART C. THE SANTA FE ROUTE, WITH A SIDE TRIP TO THE GRAND CANYON OF THE COLORADO.

By N. H. DARTON and others.

INTRODUCTION.

In going from Kansas City to Los Angeles, a distance of nearly 1,800 miles, by the Atchison, Topeka & Santa Fe Railway the traveler sees a wide diversity of geographic and industrial conditions. First he crosses the Great Plains, which extend for 500 miles, to the foothills of the Rocky Mountains. In the eastern part of these plains the rainfall is ample for crops, so that nearly all the land is in farms and the population is moderately dense. Toward the west the climate becomes increasingly arid and farms give place to scattered cattle ranches, except along some of the watercourses where irrigation is practicable. Running streams and groves of trees are numerous in the eastern part, but the watercourses in the western part are much smaller and many of them are dry in summer, and the principal trees are cottonwoods, which grow along some of the valleys.

The Rocky Mountain province is skirted by the railway from Trinidad, Colo., to Las Vegas, N. Mex., and is finally passed between Las Vegas and Lamy. It consists of a succession of high rocky ridges rising abruptly 4,000 to 6,000 feet above the Great Plains. On account of their great altitude these mountains receive considerable precipitation and in large part are forested up to timber line, which is at an elevation of about 11,000 feet. The rocks are steeply tilted, and in most of the area the granites and schists of the old earth crust have been pushed far upward and constitute the high central ranges. Over the higher parts of the uplift the sandstones and limestones under which the granites and schists were originally buried have been largely removed by the elements. Between Las Vegas and Lamy the railway crosses the north end of the great Corona Plateau, a high table-land between the Pecos and the Rio Grande which lies south of the Rocky Mountains and is related to the plateau province west of the Rio Grande.

Beyond the Rocky Mountains the traveler crosses the Rio Grande and enters the great Colorado Plateau province, which extends westward across New Mexico and far into Arizona, and many miles to the north and south. In this province sedimentary rocks predominate, in large part lying nearly horizontal, so that the harder layers constitute extensive plateaus. It contains also many great lava flows, some of which form the surface of the plateaus. Most of this province is more arid than the western part of the Great Plains. Toward the west, however, about Flagstaff, Ariz., and the Grand Canyon, where the altitude increases to 7,000 feet or more, the precipitation is much greater and luxuriant pine forests cover a wide area.

Still farther west this high plateau descends by a succession of great steps or westward-facing cliffs, and finally, near Colorado River, the traveler enters another, a very different province—the desert province of eastern California. This province consists of wide desert valleys, out of which rise long, narrow mountain ranges, most of them that lie north of the Santa Fe line trending north and south and some of them continuous for many miles. These mountains are particularly rocky and jagged and their meager vegetation is so scattered that they appear to be bare. The broad desert plains of gravel and sand likewise have but little soil and scant vegetation, for this is the most arid province in the whole country. It extends halfway across southern California to the foot of the San Bernardino Mountains and includes the Mohave Desert, a part of the vast area known as the Great Basin, whose streams do not reach the ocean but are lost in the desert. The San Bernardino Mountains and associated ranges rise as a high barrier on the west side of this basin, intercepting the moist air currents from the Pacific and thus causing the arid climate of the region to the east. These mountains are uplifted blocks of tilted rocks, largely granitic and metamorphic (altered).

The coastal-plain part of southern California extends from the western foot of these ranges to the Pacific Ocean, a distance of about 100 miles. Much of its surface is made up of coast and valley plains; its climate is mild, and although the precipitation is only moderate in amount the conditions for plant growth are so favorable that, with the help of irrigation from the streams that cross it and from water in the underlying sands and gravels, it has become one of the most productive agricultural districts in the United States.

NOTE.—For the convenience of the traveler the sheets of the route map in this bulletin are so arranged that he can unfold them one by one and keep each one in view while he is reading the text relating to it. The contour lines, in brown, represent lines of equal elevation above sea level. Each line indicates the path that would be taken by one who walked over the country by a course always at the same level, curving in and out with the irregularities of the land surface. The lines are drawn at the vertical distances apart ("contour interval") stated on each map. Where close together they indicate a steep slope; where far apart, a gentle slope or plain. A reference is made in the text to each map at the place where it should be unfolded. The areas covered by these sheets are indicated on Plate I, and a list of the sheets and the other illustrations is given on pages 187–190. A glossary of geologic terms is given on pages 182–185, and an index of stations on pages 191–194.

RELIEF MAP SHOWING SURFACE FEATURES OF THE WESTERN PART OF THE UNITED STATES.

Areas shown on the sheets of the route map are indicated in red.

ITINERARY.

Kansas City, Mo.

Elevation 750 feet.
Population 248,381.[1]

Kansas City, Mo. (see sheet 1, p. 14), is the commercial metropolis of the large area of fertile prairie plains of Kansas, Missouri, and Oklahoma. It is also an important railroad and manufacturing center and one of the great cities of the United States, ranking in 1910 twentieth in population. It covers nearly 58 square miles. Kansas City, Kans., though a distinct municipality, is really continuous with it, the two forming a single community. Most of Kansas City, Mo., is built on a rolling plateau on top of a bluff rising about 200 feet abruptly from the bank of Missouri River, but its western part is on a low flat adjoining the mouth of Kansas River, locally called the Kaw. The railway station used for many years was on this flat, at the foot of the bluff which rises steeply to the main part of the city on the east. The new station, a mile southeast of the old one, is in a depression, originally an old river channel extending across the highland.

This station and its approaches, costing $40,000,000, is the largest railway station west of New York. The building, which cost nearly $6,000,000, has room for 10,000 passengers, and 260 passenger trains arrive and depart daily on its 16 tracks.

The location and development of Kansas City were influenced by various conditions. The builders of the earliest trail found a good crossing in the big bend of the Missouri just below the mouth of Kansas River, where the bank was stable, and here a settlement, called Westport Landing, was gradually established. Later, when there were boats on the river, the deep water at this point made it a most desirable landing, and so Westport Landing soon became an important place. Here was fought a battle of the Civil War in which 29,000 men were engaged. Soon outgrowing the flat area, the city climbed the high bluff to the south, and in later years it has spread widely over the rocky plateau.

Kansas City has many factories and local industries, employing about 40,000 persons, with an annual output valued at $250,000,000. Its sales of agricultural implements aggregate $40,000,000 a year, and it ranks high in the trade in lumber, mules, hay, cigars, and grain. Meat packing is one of the important industries, for the stock yards, which cover an area of 200 acres, handle about 20,000 animals a day. The flour mills have an annual output of 4,500,000 barrels.

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[1] The figures given for the population of incorporated places are those of the United States Census for 1910. For unincorporated places the census figures give the population of the election precinct, township, or other similar unit, and such figures are here marked with an asterisk (*).

The high bluffs of Kansas City consist of thick beds of limestone and shale, about 225 feet in total thickness. The harder layers of limestone, 130 feet in all, crop out as prominent white or gray ledges. The beds appear to be horizontal, but in reality they slope (dip) at a low angle toward the northwest.[1] The limestones and shales in the bluff are part of the widely extended succession of beds which underlie Kansas, as well as the adjoining region, as shown in the sections on several sheets of the route map. The materials of which these rocks are composed were deposited many millions of years ago, at a time when a large part of central North America was covered by a sea. The limestone consists of calcium carbonate separated from the sea water by various chemical reactions, in part through the agency of sea plants and sea animals, and the shale was a mud which gradually settled from turbid water. Both kinds of sediment accumulated very slowly, and the great thickness of the rocks into which they have been consolidated represents a long period of geologic time.

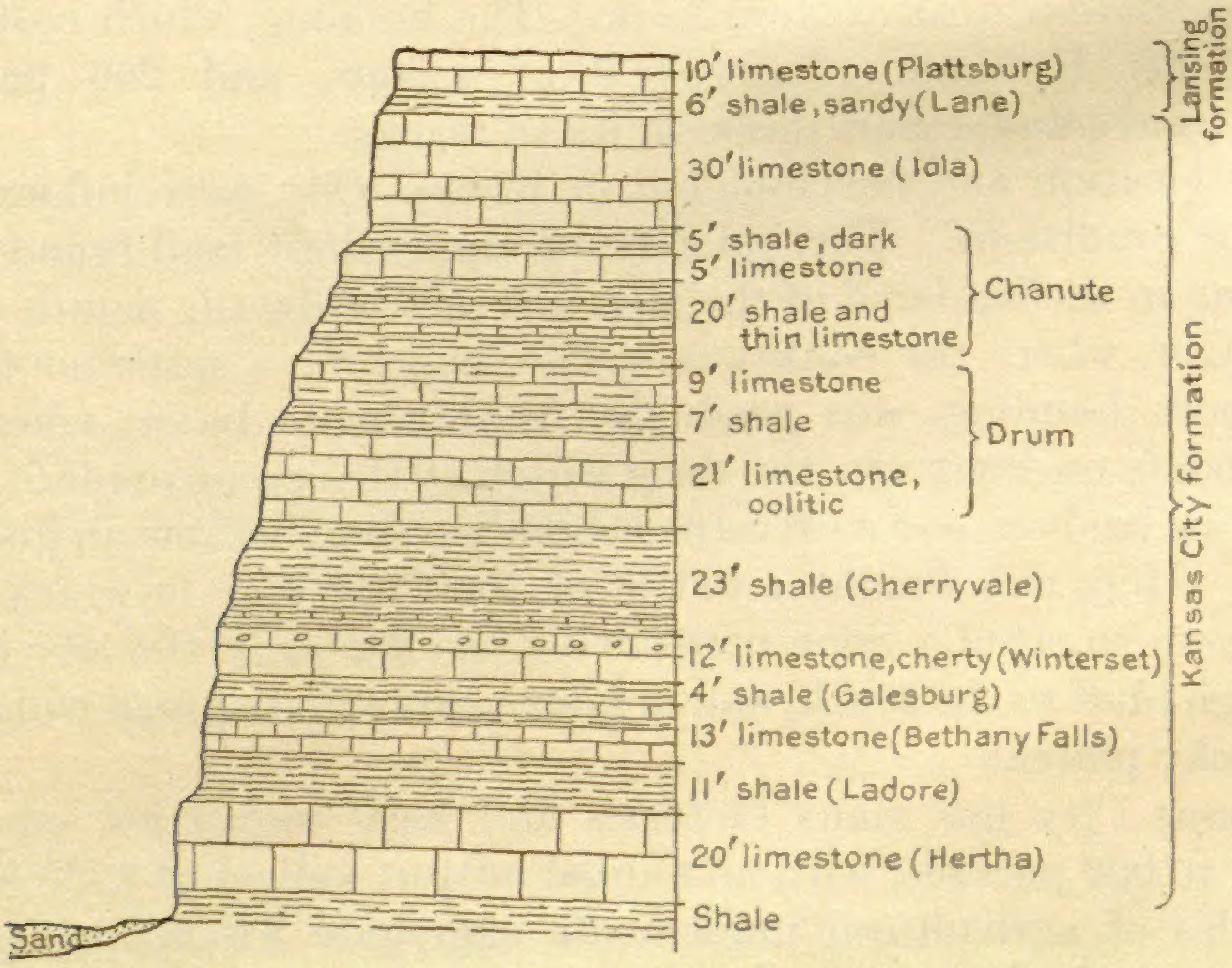

FIGURE 1.—Section of bluff at Kansas City, Mo., showing succession of limestones and shales.

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[1] These rocks are a portion of the Pennsylvanian series of the Carboniferous system. (See table on p. ii.) As shown in figure 1, they consist mainly of the Kansas City formation, the upper bed of limestone and the bed of shale underlying it representing the lower part of the Lansing formation. In accordance with the general practice among geologists each of these formations has been named from a locality where its beds are found in typical character. Some of the limestones contain impressions of fossil shells, one having yielded more than 70 species or varieties.

On the bluffs of Kansas City there is a thin sheet of sand and gravelly clay, called till, which was left by the glacier or ice sheet that once covered this region. This occupation by ice was one of the most interesting events in the geologic history of the continent.[1]

The new Union Station in Kansas City is in a marked depression or valley which lies behind the main bluff all the way from Missouri River on the east to the slopes descending to Kansas River on the west. This depression is now followed by most of the railways entering Kansas City from the east. It has walls of limestone, the harder beds appearing as ledges and the softer beds as slopes. It is floored with sand and clay to the height of about 100 feet above the present river flats. It was the valley of Kansas River at a time geologically not very remote, probably when the glacial ice extended southward as far as the city and when the valleys of the region lacked 100 feet of their present depth. The length of time that the Kansas followed this course to the Missouri was not great, but it was sufficient to cut a channel in the limestone 100 feet or more in depth. Eventually the water was drawn off by some small affluent of Missouri River at the time when that stream was cutting in its southern bank the great concave curve along which the larger part of Kansas City, Kans., now lies.

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[1] In the earlier part of the glacial epoch, called the Kansan stage, the ice sheet extended from the north halfway across northeastern Kansas, reaching the present valley of Kansas River and in places extending a few miles south of it. Probably the ice sheet had much to do with determining the position of the Kansas River valley, for the river began at that time to flow in its present general course. This ice sheet covered about 4,000,000 square miles in northern North America about 300,000 years ago and endured for a long time. It was several thousand feet thick, and it accumulated at a time when the fall of snow was in excess of melting and evaporation. Its southern edge was in the zone where melting kept pace with the advance of the ice, and apparently in some stages of its existence its margin remained at the same place for a long time. Its flow was due mainly to the thickness of the ice, for the land does not all slope downward to the south, which was the direction of the movement. The flow of a glacier of this character is illustrated in general by the lateral flow of a thick mass of pitch lying on a table.

As the glacier moved along it picked up large quantities of rock and soil. This material was slowly carried southward and in some areas accumulated at the southern edge of the ice in a deposit known as a terminal moraine. When melting gained on the rate of advance the glacial front receded and the clay, sand, gravel, and bowlders which the ice had contained were left behind in a sheet covering the rocks of the country. This deposit is called till or drift. Much of the material was brought great distances, and its coarser components, especially the bowlders, are of such character that their sources are known by geologists familiar with the rocks of the country to the north. Some of the bowlders that were carried along the bottom of the glacier are scratched by grinding against rocky ledges, and in places these ledges also show scratches and scorings which the moving rocks have cut in them. Many of the features indicative of glaciation are found in northeastern Kansas as far south as Kansas City and Topeka.

The glacier evidently extended over the area occupied by Kansas City, for glacial scratches have been observed on the surfaces of limestone ledges in the middle of the city. The scratches trend somewhat east of south and are clearly marked, having been preserved by a covering of the glacial till. This till caps the ridge in the northern half of the city but appears to thin out and disappear at no great distance to the south, indicating the southern limit of the ice. No clearly defined moraine is known in this place. The till is all on the highland, indicating that the deep river valley now lying a short distance to the north did not exist in glacial time.

Other glacial scratches are observed on the bluffs on the north side of the river 3 miles north of Kansas City, about 100 feet above the river. One set trends S. 24° W. and another S. 51° E., indicating two directions of ice movement, probably at two different stages of ice advance. Scratches are also exposed at the deep cut in the northwestern part of Kansas City, Kans. These scratches are clear cut and extend for some distance, so that they could not have been produced by bowlders in floating or floe ice.

Some of the lower slopes along the Missouri Valley in Kansas City and elsewhere are covered by a highly characteristic deposit called loess.[1] This material, accumulated at a time later than the glacial epoch, is a fine sandy loam, so thick and firm that where it is cut into by streams it makes prominent bluffs. Some of it can be seen in the eastern part of Kansas City, extending far up the limestone slopes and in part covering the glacial drift.

On leaving the Kansas City station the train rapidly descends a small valley leading into the valley of Kansas River. The south bank of this river is followed to Topeka by the old main line of the railway, but the trains that go by way of the Ottawa cut-off to Emporia follow it only to Holliday, a distance of 13.4 miles. Just before the river is reached the State line is crossed, at a point 1½ miles from the station.

Kansas.

Kansas has an area of 82,158 square miles, or nearly double that of New York, Pennsylvania, or Tennessee. Its length is about 406 miles, but the Santa Fe Route, in crossing it from east to west, covers about 465 miles. The population of the State, according to the census of 1910, was 1,690,949. The density of population averages 20.7 to the mile but is much greater in the eastern part of the State and far less in the western counties. Kansas was part of the Louisiana Purchase of 1803, and when Missouri was made a State its eastern boundary was defined, but for many years the region west of that line was regarded as an Indian country with no prospect of white settlement. This region was crossed by the Lewis and Clark expedition in 1804 and by Lieut. Pike in 1806.

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[1] Geologists differ in accounting for the origin of the deposit known as loess, but many of them believe that while rivers may have cooperated in its accumulation, most of it was at one time or another wind-blown dust.

In 1854 Kansas was organized as a Territory under the Kansas-Nebraska act, which left the question of slavery to be settled by vote. This question caused several years of bitter contention, in which many persons came from far and near to join. The struggle of the slavery and antislavery forces finally became a national issue and was one of the causes of the Civil War. In 1861 Kansas was admitted as a "free State." It has been settled by a great variety of people, some of whom have come in large bodies. After the Civil War many soldiers settled in the State, taking advantage of the provision that a person who had given military service could have his term of service deducted from the five years required for homesteading.

Kansas has considerable resources in oil, coal, cement rock, and other minerals, but the principal industry of the State has been agriculture, and in this she has taken high rank. Kansas produces about one-tenth of our wheat, ranking first in that crop. Nearly 5,500,000 acres is planted in wheat, and the average annual yield from 1900 to 1913 was 75,347,000 bushels, but in 1914 the crop was 177,200,000 bushels, valued at $168,340,000, or more than ever before. The oat crop in that year was 58,960,000 bushels, and the estimated total value of farm and live-stock products of Kansas for 1914 was $638,000,000, or nearly double the cost of the Panama Canal. The average yield of wheat in Kansas for the last 10 years is 14.1 bushels to the acre, and the State ranks twenty-sixth in that respect. The average yield of wheat for the United States is 14.8 bushels to the acre. Indian corn is an important crop in Kansas, the yield in 1913 being 174,225,000 bushels.

The mineral products of Kansas in 1913 had an aggregate value of $27,312,563. Coal ($12,036,292) was the leading item, and Portland cement (3,291,818 barrels, valued at $3,268,861) ranked second. The zinc produced was valued at $1,129,856; lead, $213,576; clay products, nearly $2,000,000; salt, nearly 2,700,000 barrels, valued at $860,000; petroleum, 2,375,029 barrels, valued at $2,248,283.

On the north side of the river is a wide, low flat, on which is built the southern part of Kansas City, Kans. The flat consists of sand and gravel deposited by the river and extending to steep slopes of limestone on the north. The valley of the Kansas is from 2 to 3 miles wide, and the stream meanders across its bottom in long, swinging bends, skirting the limestone bluff on one side for a few miles and then crossing to the other side. Features of this sort are common to all large streams that carry sediment across a generally flat country, especially to those which vary greatly in volume at different times in the year. Kansas River i noted for its floods, which follow exceptionally heavy or protracted rains. During their progress the volume of water in the stream is enormously increased. Overflowing the ordinary channel, the water extends widely over the lower lands, and as its velocity is also greatly increased, it does much damage. As the stream is well known to be subject to floods, many precautions have been taken to make railway embankments, bridge abutments, and other structures along it sufficiently high and strong to withstand them, but occasionally a very high flood causes great havoc.

The great flood early in June, 1903, was the highest since the flood of 1844 and was more destructive than that one because of the greater population in the valley. The water extended from bluff to bluff at most places, but fortunately there were many localities at which the current was not strong. At the Union Pacific station, in Topeka, there was from 7 to 8 feet of water and at the Kansas City Union Station the water was nearly as deep. There was great loss of life and property, a large amount of mud was deposited, and the river's course was changed in places. The flood was caused by exceptionally heavy rainfall at the end of a long rainy season, which had saturated the ground and increased the flow of all the streams in the region.

West of the Missouri-Kansas State line Kansas River makes a large bend to the south, cutting into the limestone slope of the valley so that a prominent bluff rises steeply above the stream. This bluff, which extends to Argentine, is nearly 200 feet high and exposes the same beds of limestone and shale that are seen in the bluffs farther downstream. The railway is built on a cut and fill at its foot.

Argentine, Kans.
Elevation 750 feet.
Kansas City 5 miles.

Argentine, the first stopping place in Kansas, was named from the Latin word for silver (argentum), smelting being the first industry established there. It is a part of Kansas City, Kans. West of Argentine for a few miles the railway leaves the immediate river bank and runs near the foot of a wooded bluff, in which may be seen most of the limestone beds that are exposed at Argentine and Kansas City. Chief among these is a 30-foot bed of the Iola limestone, which is used extensively for the manufacture of Portland cement at Iola, in southeastern Kansas. Next above is shale (Lane shale), and at the top of the bluff is a succession of limestones (the Stanton and Plattsburg limestones). All the beds descend gradually to the west, for the dip is mostly in that direction, and the land also rises as the valley is ascended. The grade of Kansas River is low; the rise from its mouth at Kansas City, where the elevation above sea level is about 720 feet, to Topeka is only about 150 feet. As the distance is 65 miles, the slope is less than 2½ feet to the mile.

Near milepost 9 and again from a point west of milepost 11 nearly to Holliday the railway is on the bank of the river. At milepost 13, east of Holliday, there is a cliff of Drum limestone, a bed which gradually descends toward the west and passes beneath the river near Wilder. Holliday was named for C. K. Holliday, of Topeka. From this place the cut-off line leads westward to Emporia. This line is described on pages 19–22.

Holliday.
Elevation 760 feet.
Kansas City 13 miles.

Beyond Holliday the main line [1] follows a nearly west course for 3½ miles along the southern margin of the Kansas River flat. At Wilder siding the valley makes a sharp turn to the southwest along the outcrop of the upper beds of the Chanute shale, which underlies the Iola limestone. The course of the valley, however, was established long before these soft beds were cut into at this place. Probably its position was influenced by the ice sheet of the glacial epoch, the southern edge of which appears to have projected several miles farther south in this vicinity than in the regions to the east and west. The ice occupied the highlands north of the river, but it is believed not to have extended south of the present stream between the western part of Kansas City and Lawrence.

Wilder.
Elevation 772 feet.
Kansas City 17 miles.

At Bonner Springs, across the river from Wilder, there are large quarries of limestone. The hills north of the river, from a point opposite Wilder to a point beyond Weaver, are capped by till containing scattered bowlders brought from the north by the glacial ice. One of these bowlders, about 8 miles north of Topeka, is 40 feet long and 25 feet high and weighs about 1,500 tons. In large quarries on the north bank of the river opposite milepost 8 the limestones are worked for ballast, road metal, and concrete material. When the clay and till were removed from the limestone many glacial scratches were uncovered. They bear S. 20° E. and give unmistakable evidence that glacial ice moved in that direction across the country before the present valley was excavated. The rock fragments carried in the base of the ice scored the limestone surface. Probably an earlier Kansas River flowed along the south edge of the ice sheet and received much water from the melting ice.[2]

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[1] On this line the mileposts indicate distance west of Holliday as far as Topeka, beyond which they indicate distance from Atchison.

[2] At one stage of the excavation of the valley, probably while the ice extended to the line of the present valley at Wilder, the river flowed eastward across the ridge a mile south of Wilder, for an old high-level gravel and sand bed is found on the east slope of this ridge. The river did not flow long in this course, for it cut only a small valley through the ridge, which forms the present divide.

The gentle northwesterly dip which prevails in eastern Kansas brings the Iola limestone almost to river level at De Soto. The south abutment of a bridge across the river here rests on this limestone, which shows for a short distance in the bank and finally passes beneath the alluvial filling of the river flats. About 8 miles farther west, the next overlying limestones (the Stanton and Plattsburg) in turn pass beneath the river flat near Eudora. As the formation above them is soft, easily eroded shale, the bluffs along the valley sides here greatly diminish in height and steepness.

Eudora.

Elevation 813 feet.
Population 640.
Kansas City 33 miles.

Eudora was named after the daughter of a Kansa chief, Pascal Fish, from whom the site was purchased. Here the railway crosses the mouth of Wakarusa Creek, which occupies a wide valley extending far westward. This valley is wide mainly because it has been excavated by a good-sized stream in a thick body of soft shales but also because at one time, probably during the glacial epoch, it served as a channel for Kansas River. Since that time, however, all the valleys of the region have been cut about 100 feet deeper. Another old channel of Kansas River extends across the wide bench on the north side of the present valley, 4 miles south of Eudora, about 150 feet above the river. This channel, however, is older than the one in Wakarusa Valley, for it is higher and the coarser materials in it are largely flint of local origin. This channel is believed to be preglacial, because its deposits show none of the rocks of northern origin which were later spread over this region by the glacier.

The flat at the junction of the Wakarusa and Kansas valleys is wide and shows terraces of moderate height, which extend some distance west of Eudora. The railway passes over this flat, and in places, as at milepost 23, its course is 2 miles south of Kansas River.

The wide flats along Kansas River contain a thick mass of sand and loam deposited by the river. This material affords excellent soil at most localities, and from Kansas City to and beyond Topeka it is cultivated for corn, vegetables, and other crops, which are highly profitable. Unfortunately some parts of this land are not out of the reach of ordinary freshets, and a large area is subject to flood and damage when the river is exceptionally high. Heavy freshets, however, are so rare that many farmers take the chances of damage by high water.

From points not far beyond Eudora the highlands south of the river are visible. Their prominence is due to a thick cap of hard, massive limestone which protects the soft underlying shale from erosion. One high butte known as Blue Mound, 5 miles southwest of Eudora, is capped by an outlying mass of this limestone, and other peaks and hills farther southwest present the same feature.[1]

The thick Oread limestone and the great mass of soft shale below it form one of the most prominent of the long "steps" crossing the plateaus of eastern Kansas. The formation passes under 90 feet of Kanwaka shale to the west, and it dips beneath the valley of Kansas River near Lecompton.

At the east edge of Lawrence the Santa Fe line is crossed by a branch of the Union Pacific system coming from the north side of Kansas River.

Lawrence.

Elevation 822 feet.
Population 12,374.
Kansas City 40 miles.

The State University of Kansas is in the southwestern part of Lawrence. The group of university buildings on the ridge known as Mount Oread[2] is about a mile southwest of the railway station and can be reached by trolley cars. The university enrollment is about 1,200 students, mostly residents of Kansas, to whom tuition is free. Connected with the university is the State Geological Survey, which has published many reports on the geology and mineral resources of Kansas.

Haskell Institute, a Government school for young Indians, established in 1884, is situated in the southern part of Lawrence. Most of these Indians come from the several reservations near by. The number of students is 800.

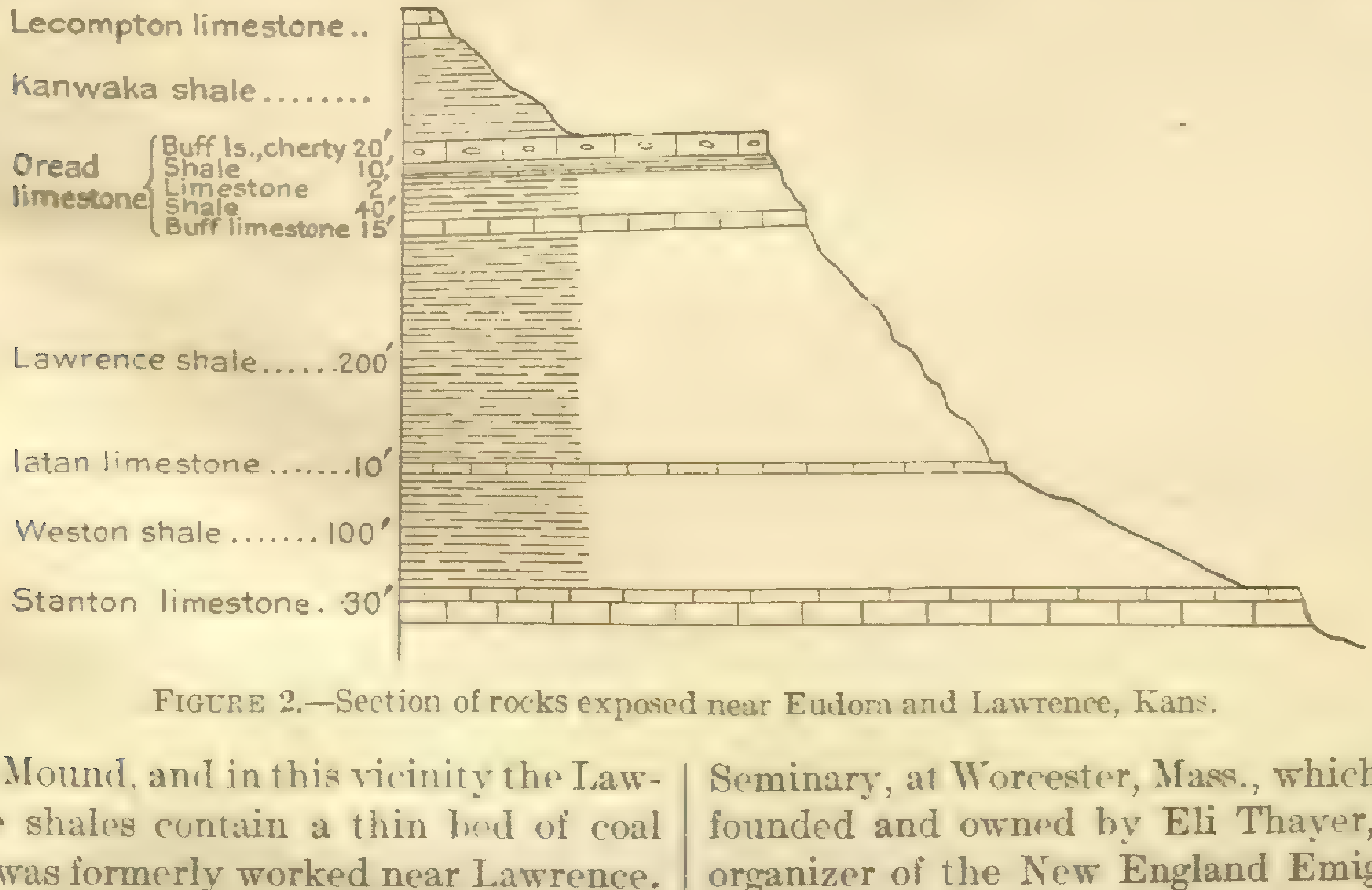

FIGURE 2.—Section of rocks exposed near Eudora and Lawrence, Kans.

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[1] The succession of rocks near Eudora and Lawrence is shown in figure 2, below. The Iatan limestone (formerly called the Kickapoo) is 10 feet thick at the base of Blue Mound, and in this vicinity the Lawrence shales contain a thin bed of coal that was formerly worked near Lawrence. The limestone and shales constituting the Oread limestone cover a wide area but vary somewhat in thickness from place to place.

[2] This ridge was named by the first party of settlers in honor of Mount Oread Seminary, at Worcester, Mass., which was founded and owned by Eli Thayer, the organizer of the New England Emigrant Aid Society.

Lawrence was settled by a colony of New England people who were ardent advocates of the abolition of slavery. The attempt to make Kansas a proslavery State was prosecuted with zeal, and vigorous endeavor was made to keep out settlers who were not in sympathy with that side. On the other hand the abolitionists of the East organized companies which established and assisted in maintaining "free-soil colonies." The New England Emigrant Aid Society, of which Amos A. Lawrence, of Boston, was an active member, was responsible for the settlement of Lawrence, Kans., in 1854. From this time to the Civil War the town was the stronghold of the antislavery party. In 1863 Quantrell raided Lawrence with a band of Missourians who killed 288 men, a large proportion of the adult male population at the time. Lawrence was a noted station on the so-called underground railroad system by which slaves escaped from Missouri and other States.

At Lawrence brick of various kinds is made from shale, and sand is dredged from the river for use in making concrete and other building operations. The dredge is plainly visible from the railway station (to the north), and the principal brickworks are south of the railway, a mile west of the station. In the pits the shale is capped by terrace deposits. A 1,400-foot well just east of Lawrence station furnishes a small flow of saline water that is in considerable demand for the treatment of rheumatism. The river is dammed at Lawrence to afford power, which is used mainly by a flour mill.

Much stone is quarried from the ledges of Oread limestone west of Lawrence. About 90 feet of shale (Kanwaka) intervenes between the Oread and the next higher limestone (the Lecompton),[1] which caps the ridges southwest of Lawrence. The Lecompton limestone dips west and passes below the alluvium of the valley filling near Spencer siding. In quarries north of Kansas River it yields large slabs that are used in Lawrence and other places for curbing, pavements, and trimmings.

Half a mile west of Lawrence station, on the north side of the railway, are the city waterworks. Water from the underflow of the river is obtained by large pits, in the bottom of which perforated pipes are sunk deep in the sand. The railway passes along a flat with low terraces on the south side that extend to the foot of a wooded bluff capped by ledges of limestone.

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[1] The Lecompton limestone consists of five principal beds; 5 feet of limestone at the base, 5½ feet of shale, 16 inches of blue limestone, 4 feet of shale, and 10 feet of light-gray limestone which disintegrates easily. Great quantities of the peculiar fossil, Fusulina, occur in the basal part of the Lecompton limestone. It is a foraminifer of elongated oval form, generally about a quarter of an inch in length, and is common also in higher limestones. The shale that overlies the Lecompton limestone, known as the Tecumseh shale, is about 75 feet thick and includes two thin limestone beds which make riffles in the river.

Lakeview.

Elevation 830 feet.
Kansas City 45 miles.

Near Lakeview several old sections of river channel or oxbows are conspicuous. They are now abandoned by the main stream, which passes north of them, but are in part filled with water. Features of this sort are common along streams flowing in a wide alluvial flat, for in nearly every freshet sand banks accumulate which dam up an old course for a few miles while a new channel is scoured out by the strong current deflected in another direction.

Long ago Kansas River cut its valley about as deep as is possible with the low grade finally attained, and since that time the flats have been in process of being built up. The valley is being widened, however, for every few miles along its course the stream cuts into its banks and removes more or less of the limestone and shale. This cutting shifts in location from time to time, and some of these old cut banks now rise from old channels long ago abandoned. As its banks are cut back the river valley gradually widens, and if the process continues sufficiently long the side valleys also will be widened in the same manner and the adjoining highlands disappear.

In the region west of Lawrence the ice sheet of the Kansan glacial stage extended several miles south of the present Kansas River valley, for the south margin of the drift covers the greater part of the high ridge between that river and the valley of Wakarusa Creek. The drift margin continues in this position to Topeka and beyond, but it is hardly perceptible to the traveler on the railway, which follows the relatively recent river bottom. The rolling hills that can be seen on the upland in places north of the river consist largely of glacial drift.

Lecompton.

Elevation 846 feet.
Population 386.
Kansas City 51 miles.

Lecompton (see sheet 2, p. 22) was the capital of Kansas Territory from 1855 to 1861 and was named from D. S. Lecompte, chief justice of the Territory. It was a noted proslavery stronghold and a rival to Lawrence. The "Lecompton constitution," under which the proslavery party wished Kansas to become a State, was drawn up at a constitutional convention called at Lecompton in 1857. This constitution was overwhelmingly defeated by popular vote. Toward the end of the free-soil troubles the Territorial legislature was accustomed to convene in Lecompton and adjourn at once to Lawrence. Those days of political turmoil are happily past, and now Lecompton is a quiet little village.

Between mileposts 38 and 39 the Lecompton limestone crops out in ledges south of the track for some distance, but farther west there are wooded slopes which show limestone only at intervals. These slopes continue beyond Grover.

Tecumseh.

Elevation 862 feet.
Population 1,024.*
Kansas City 62 miles.

Tecumseh is on a low terraced slope in a sharp bend of the river. The name is that of a Pawnee chief and means panther. From Tecumseh low river terraces extend westward for nearly a mile, to a point at which they give place to a wide, low flat that extends to Topeka.

Topeka.

Elevation 886 feet.
Population 43,684.
Kansas City 66 miles.

Topeka, the State capital, is one of the largest cities in Kansas. It has broad, well-paved streets, with parking and shade trees. Its name is an Omaha Indian word signifying the so-called Indian potato. It is a division point on the Santa Fe Railway and the place of convergence of several branch lines and other railways. The general offices and extensive shops of the Santa Fe system are situated here, and there are many factories and local industries of various kinds, including quarries, brickyards, sand pits, large flour mills, and what is said to be the largest creamery in the world. It was from Topeka that the Santa Fe Co. began building a railway westward in 1869, but it did not reach Santa Fe until 1880.

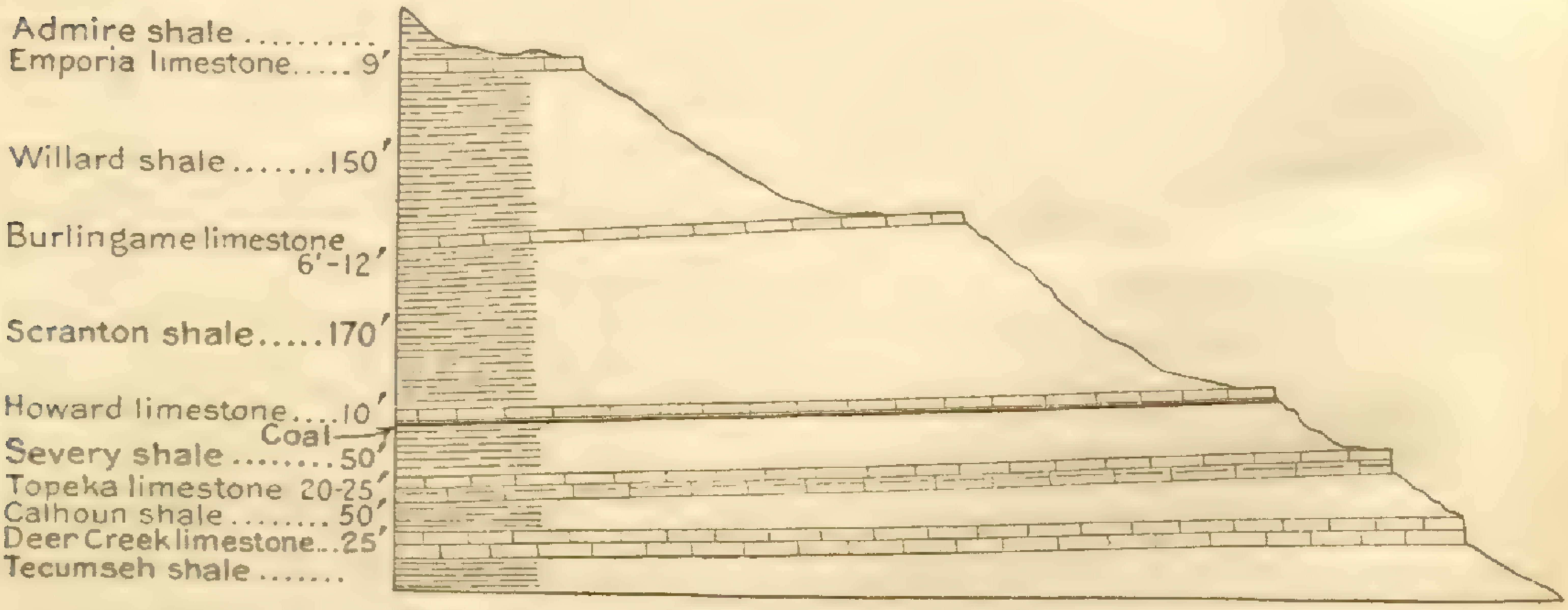

FIGURE 3.—Section showing succession of rocks in plateau south of Topeka, Kans.

Topeka was the scene of many riots during the conflict between the abolitionists and the advocates of slavery. Here in 1856 the Free Soil legislature, meeting in opposition to the proslavery legislature, was dispersed by United States troops acting under orders from President Pierce. Five years later, after numerous elections and conflicts, the first State legislature assembled in Topeka.

On leaving Topeka[1] the train goes nearly south up the valley of Shonganunga Creek and then up one of its branches which heads at the top of the plateau. The ascent is made by a moderate grade, about 125 feet in 5 miles. This plateau is made up of a succession of limestones and shales, shown in figure 3. A few ledges of limestone

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[1] Mileposts from Topeka to Isleta indicate distance from Atchison.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
SANTA FE ROUTE
From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

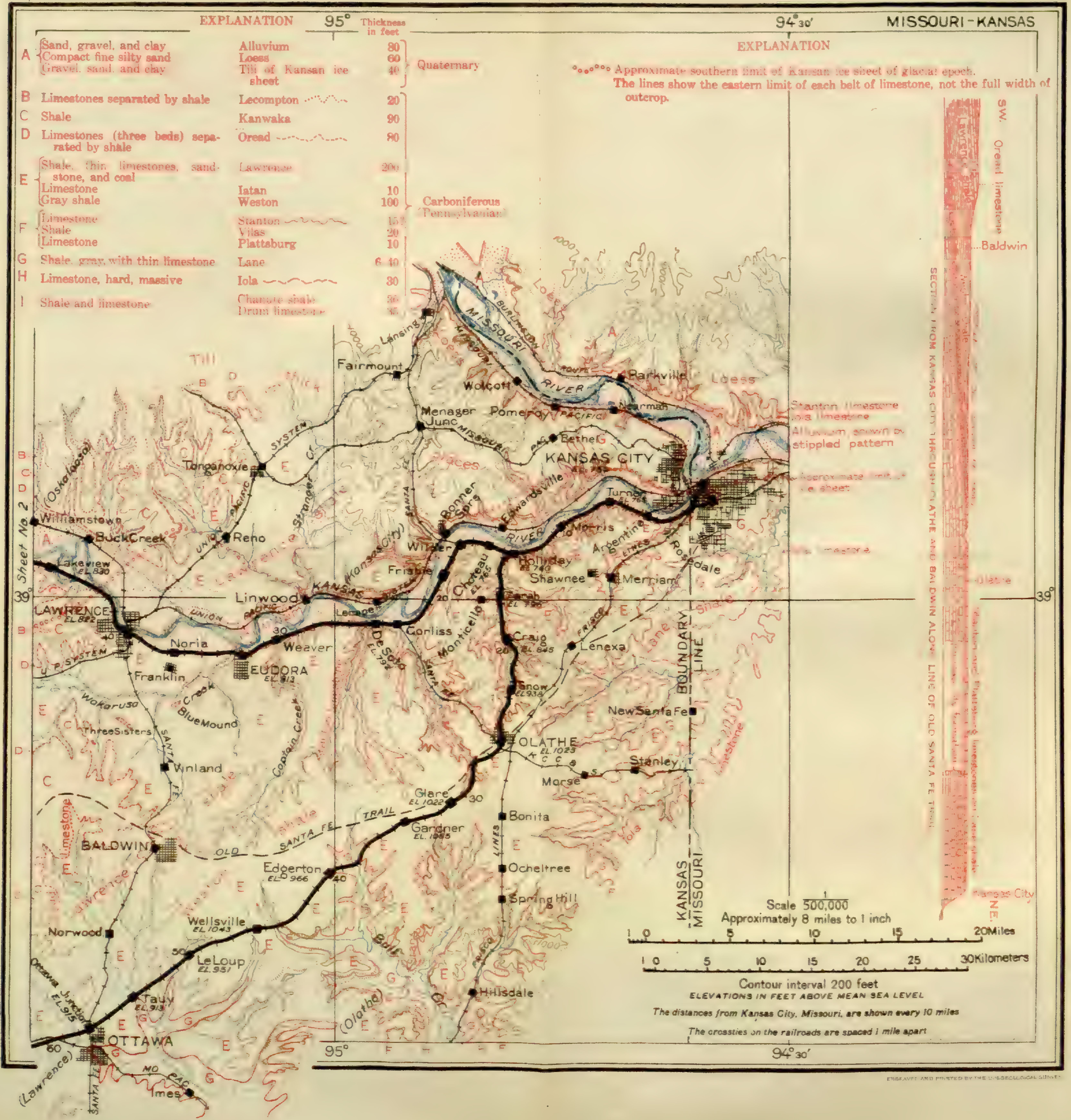
UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.


MISSOURI-KANSAS
EXPLANATION
Thickness in feet
A Sand, gravel, and clay — Alluvium — 80
Compact fine silty sand — Loess — 60
Gravel, sand, and clay — Till of Kansan ice sheet — 40
Quaternary
B Limestones separated by shale — Lecompton — 20
C Shale — Kanwaka — 90
D Limestones (three beds) separated by shale — Oread — 80
E Shale, thin limestones, sandstone, and coal — Lawrence — 200
Limestone — Iatan — 10
Gray shale — Weston — 100
Carboniferous (Pennsylvanian)
F Limestone — Stanton — 15
Shale — Vilas — 20
Limestone — Plattsburg — 10
G Shale, gray, with thin limestone — Lane — 6-40
H Limestone, hard, massive — Iola — 30
I Shale and limestone — Chanute shale — 30
Drum limestone — 35
EXPLANATION
Approximate southern limit of Kansan ice sheet of glacial epoch.
The lines show the eastern limit of each belt of limestone, not the full width of outcrop.
95°
94°30'
39°
SECTION FROM KANSAS CITY THROUGH OLATHE AND BALDWIN ALONG LINE OF OLD SANTA FE TRAIL
SW.
NE.
Oread limestone
Baldwin
Kansas City
Stanton limestone
Iola limestone
Alluvium shown by stippled pattern
Approximate limit of ice sheet
KANSAS CITY
MISSOURI RIVER
KANSAS RIVER
LAWRENCE
OLATHE
OTTAWA
BALDWIN
EUDORA
Lansing
Fairmount
Wolcott
Parkville
Menager Junc
Pomeroy
Bethel
Turner
Morris
Argentine
Rosedale
Merriam
Shawnee
Holliday
Wilder
Frisbie
Bonner Springs
Edwardsville
Linwood
Lenape
Corliss
Weaver
Noria
Franklin
Tonganoxie
Reno
Williamstown
Buck Creek
Lakeview
Wakarusa
Three Sisters
Blue Mound
Vinland
Captain Creek
De Soto
Monticello
Chateau
Sarah
Craig
Lenexa
Snow
New Santa Fe
Stanley
Morse
Glare
Bonita
Gardner
Ocheltree
Edgerton
Spring Hill
Wellsville
Le Loup
Norwood
Hillsdale
Tauy
Imes
Ottawa Junction
(Oskaloosa)
(Lawrence)
(Olathe)
(Kansas City)
Sheet No. 2
OLD SANTA FE TRAIL
UNION PACIFIC
SANTA FE SYSTEM
MISSOURI PACIFIC
FRISCO
BURLINGTON
KANSAS MISSOURI BOUNDARY LINE
Loess
Till
Scale 1/500,000
Approximately 8 miles to 1 inch
0 5 10 15 20 Miles
0 5 10 15 20 25 30 Kilometers
Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart

ENGRAVED AND PRINTED BY THE U.S.GEOLOGICAL SURVEY

crop out in the slopes of these valleys. These beds are of late Carboniferous age and slope at a very low angle to the west.

Pauline.
Elevation 1,029 feet.
Kansas City 72 miles.

A mile south of Pauline the railway crosses the line of the old high valley through which in glacial time Kansas River flowed across the divide into the valley of Wakarusa Creek. This deflection of the drainage to the south was probably caused by the advance of the great ice sheet southward between Lawrence and Topeka. The ice blocked up the older channel, which was in a general way coincident with that of the present valley but, as explained on page 10, at a higher level, for the old channel across the divide is about 150 feet above the present river. It is marked by a broad depression and especially by deposits of sand and numerous bowlders, some of them very large and easily recognized as having been brought by the ice from regions far to the northwest. The relations of this stream deposit are not well exposed along the railway but are clearly exhibited along the stream and slopes northwest of Pauline station.

At the time when the river passed in this direction it carried the drainage of the west side of the glacial ice from the Dakotas and Nebraska far to the north, and its volume was therefore much greater than at present. It cut a valley toward the east, now occupied by Wakarusa Creek, which, however, has deepened its channel considerably, leaving remnants of the old deposits on the valley sides.

West of Pauline the land rises abruptly in a step due to the outcrop of a hard bed of limestone. This step or ridge is a conspicuous feature for the next 40 miles, the railway skirting the shale slopes and plains at various distances from its foot. The succession of cliffs due to the hardness of limestone and of slopes due to the softness of shale is characteristic of the eastern part of Kansas, especially in the drift-free area south of Kansas River. The rocks consist of alternations of beds of hard limestone, mostly from 5 to 25 feet thick, and of shale, from 25 to 100 feet thick except the Lawrence shale, whose thickness is 200 feet. The beds all dip at a slight angle to the west, and as the country is rolling upland, the limestone beds rise in sloping ledges, usually terminated on the east by cliffs of varying degrees of prominence. These cliffs cross the country from north to south at intervals of 3 to 5 miles, the distance depending on the thickness of the intervening shales and in some places on slight variations in the dip. From a high point in this area can be seen the long westward-sloping steps of limestone and the intervening rolling plains and gentle slopes of shale.

Nearly all of the area is in a high state of cultivation, producing large crops of grains and vegetables. The soil is rich, and a fair proportion of the rainfall, which averages 35 inches a year, comes at the time when crops are growing.

A short distance south of Pauline the summit of the divide, which is on the Scranton shale, is reached at an altitude of 1,050 feet; thence there is a down grade to the village of Wakarusa. Here the railway crosses Wakarusa Creek at a point where the stream has cut through the shales to the Topeka limestone, a ledge of which is exposed in the shallow railway cut a few rods north of the station. South of Wakarusa the track rises from the creek valley to a rolling plain, whose altitude is from 1,000 to 1,075 feet. At milepost 64 a 4-foot bed of limestone is crossed by the railway. In the higher portions of the ridges traversed in the next 3 miles there are several cuts in shales, some of which expose thin included beds of limestone.

Wakarusa.
Elevation 948 feet.
Kansas City 78 miles.

Between Carbondale and Osage there are many small coal mines and numerous abandoned pits and long open cuts. Several of the mines produce a moderate amount of coal for local use and for shipment to various places in eastern Kansas. They are from 10 to 140 feet deep, and at most localities the bed is from 16 to 22 inches thick. Some of the coal has been mined by stripping off the soil and débris and more or less shale along the outcrop, but to the west, as the dip carries the coal deeper, it is reached by shafts. For many years this field was the principal source of supply of fuel for the Santa Fe Railway, and several of the mines were worked by the railway company until other sources of coal were developed. In 1893 and 1894 the annual output exceeded 200,000 tons. The coal[1] is bituminous, and although it is not all of high quality this thin bed has been worked with considerable profit. It is known to extend to Lebo and Neosho Rapids, and it is only about 250 feet deep at Emporia.

Carbondale.
Elevation 1,074 feet.
Population 461.
Kansas City 84 miles.

About the coal mines from Carbondale to Osage are heaps of gray shale excavated in sinking shafts and extending the coal chambers. In places where this débris has contained considerable coal waste it has been ignited at times by spontaneous combustion and the heat has given it a bright-red color, which makes the piles conspicuous. The Howard limestone is traversed a short distance north of milepost

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[1] Coal consists of carbonaceous material, originally trees and other plants of various kinds, that accumulated in swamps and was finally covered by mud. At the time when such material accumulated in this region it was an area of widespread swamps and morasses with rank vegetation. Later it was covered by the sea, in which were deposited the materials now represented by the limestone and shale. The coal bed is only a few feet below the Howard limestone, which is therefore a guide to the location of the coal. The limestone and shale in this region are of the same age (Carboniferous) as the rocks which contain the great deposits of coal in Pennsylvania, West Virginia, Indiana, Illinois, Ohio, Tennessee, and Alabama. Here, however, deeper water prevailed for much of the time and conditions favorable to the accumulation of coal were relatively transient and local.

70, on the descent to Hundred and Ten Mile Creek, which is crossed 1 mile north of Scranton.

Scranton.

Elevation 1,100 feet.
Population 770.
Kansas City 87 miles.

The principal industry about Scranton is coal mining, but in the surrounding country there are also extensive agricultural interests. From Scranton southwest and west to Burlingame the route crosses a nearly smooth plain of shale which extends far to the east and for some distance to the west.

Burlingame.

Elevation 1,045 feet.
Population 1,422.
Kansas City 92 miles.

At Burlingame the railway crosses the line of the Santa Fe Trail from Kansas City to Santa Fe, N. Mex.[1] This trail followed the top of the plateau from Olathe and went west from Burlingame 30 miles to Council Grove, which was an important depot. Quantrell planned to raid the town of Burlingame in 1863, while the men were absent in the Army, but the women built a fort of rocks and held their ground for six weeks until Union soldiers came to their assistance. This town was named for Anson Burlingame, formerly United States minister to China.

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[1] This famous old highway was about 850 miles long. From 1804 to 1821 it had been traveled by a few trading expeditions using pack animals, but in 1821 it was formally opened for wagon travel, and caravans of "prairie schooners" and large wagons began to make their trips to the excellent market of Santa Fe, then an important Government and commercial distributing city of the northern part of old Mexico, and a point from which highways and trails extended down the valley of the Rio Grande and elsewhere. Later, after the United States had acquired the region, until the Santa Fe Railway was built, the trail was one of the great emigrant routes to the Southwest. At first the traders made only one trip a year, starting early in summer, as soon as the pasturage was promising, and arriving at Santa Fe in July. Early in the sixties the trade had increased to so great an extent that the caravans started every few days, and many were on the road during the season favorable for such travel.

The ordinary caravan consisted of 26 wagons, each drawn by five teams of mules or five yoke of oxen, but often there were 100 wagons in a caravan, divided into four divisions, a lieutenant having charge of each division under the command of an elected captain of the whole party. A day's journey was about 15 miles, but varied slightly with the distances to camping places. At night the wagons were formed into a hollow square inside which camp was made and the horses were corralled. Outposts were maintained for sentry duty, as the Indians often attacked such parties just at dawn.

East of Council Grove there was little to fear from the Indians, who were friendly to the white men. The Kansa tribe of Sioux had settled at the mouth of Kansas River but, persuaded by gifts, they abandoned one settlement after another as immigration progressed. So accommodating a spirit was not found among the tribes of the central Great Plains. The earlier trappers and frontiersmen had found most of these Indians amicable, but misdeeds by individuals of both races led to general bad feeling and convinced the Indians that they had nothing to gain from friendliness. Their hostility added greatly to the danger of travel on a trail that was already perilous enough through its lack of water and its physical obstacles.

In 1850 there were about 500 wagons and about 5,000 animals in the service, and in 1866 there were 3,000 wagons. On

Several coal mines are worked in the vicinity of Burlingame. A short distance west of the railway rises a prominent ledge of the Burlingame limestone, of which this is the type locality.

Beyond Burlingame the railway goes south and east of south across an undulating plain, making shallow cuts through the Scranton shale, which lies between the Howard limestone and the Burlingame limestone.

Osage.
Elevation 1,077 feet.
Population 2,432.
Kansas City 101 miles.

At Osage the Santa Fe crosses the Missouri Pacific Railway. The city is named from the Osage Indians, a branch of the great Siouan family, some of whom formerly lived near the Kansa Indians, north of the Arkansas. In addition to its coal-mining industry, it is the center for the surrounding farming community. The rolling plain of shale continues from Osage southwestward to Reading. The highest altitudes attained on the divides are 1,165 feet, or slightly higher than in the region to the north.

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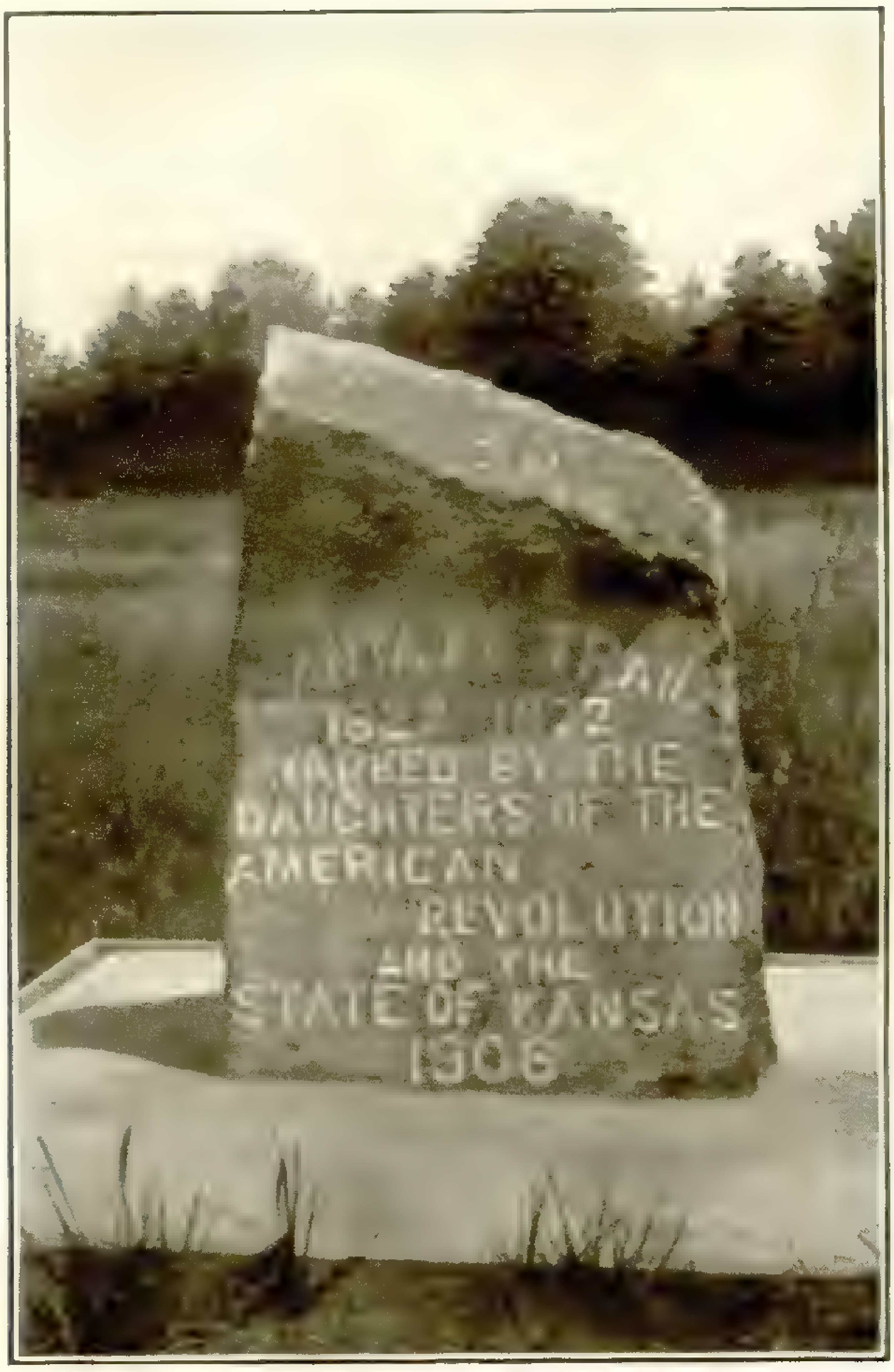
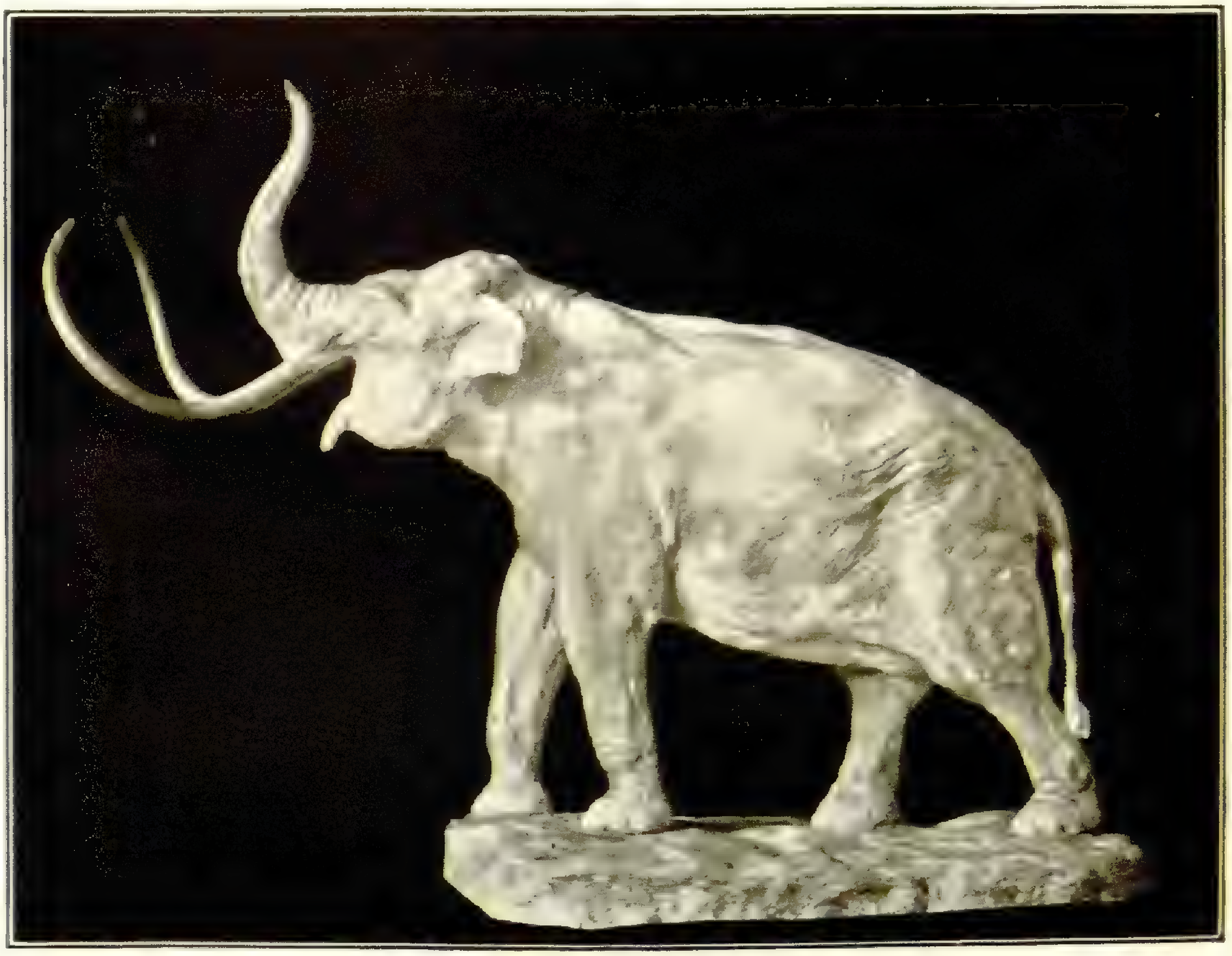
some trips as many as 180 yoke of oxen would haul two trains of wagons. In 1849 regular coach service carrying mail from Independence to Santa Fe was started, and in 1862 the service was daily. The trip required two weeks. The coaches carried 11 passengers, who were charged $250 each for the trip, including meals. The cost of the trip from Kansas City to Santa Fe now, including meals and sleeper, is less than $35 and the time required is 15 hours. Express charges for carrying money were $1 a pound for gold or silver.

The Santa Fe Railway follows the old trail in general, but in places the two are not very close together. In eastern Kansas there were several lines of travel. One began at Independence, Mo., a short distance east of Kansas City, crossed the river to Westport, passed through the hills in Kansas City, and then went by Olathe and Gardner over the plateau southeastward to Council Grove, a famous rendezvous 25 miles northwest of the present city of Emporia. About halfway to Council Grove it was joined by a route from Fort Leavenworth, where most of the Government troops outfitted. The Santa Fe Railway now crosses this part of the trail near Olathe and again near Burlingame, about halfway between Topeka and Emporia. West of Council Grove the trail passed through the southern part of the city of Lyons, reaching Arkansas River near Ellinwood, a short distance east of Great Bend. From this place westward it followed the north bank of the river, in greater part within a very short distance of the course now taken by the railway, but in Colorado it kept on the north bank to Bents Fort, above Las Animas, where it crossed to the south side of the river. From this point into New Mexico the trail led southwestward, along a course very near the line of the present railway which crosses and recrosses it all the way to Raton. South of that place the trail went through Cimarron to Fort Union, near Watrous, thence to Las Vegas and across the Glorieta Pass to Canyoncito, whence it turned north to Santa Fe. A short-cut branch crossed the Arkansas above Dodge and went southwest to the Cimarron Valley and thence to Wagon Mound and Fort Union. Along much of its course the old trail is marked by granite monuments erected by the Daughters of the American Revolution. (See view of typical monument given in Pl. II, *A*.) The tracks of the trail are 200 feet wide in many places and consist of old ruts deeply scored into the sand. Sunflowers spread westward along the entire length of the trail and now mark its course at many places.



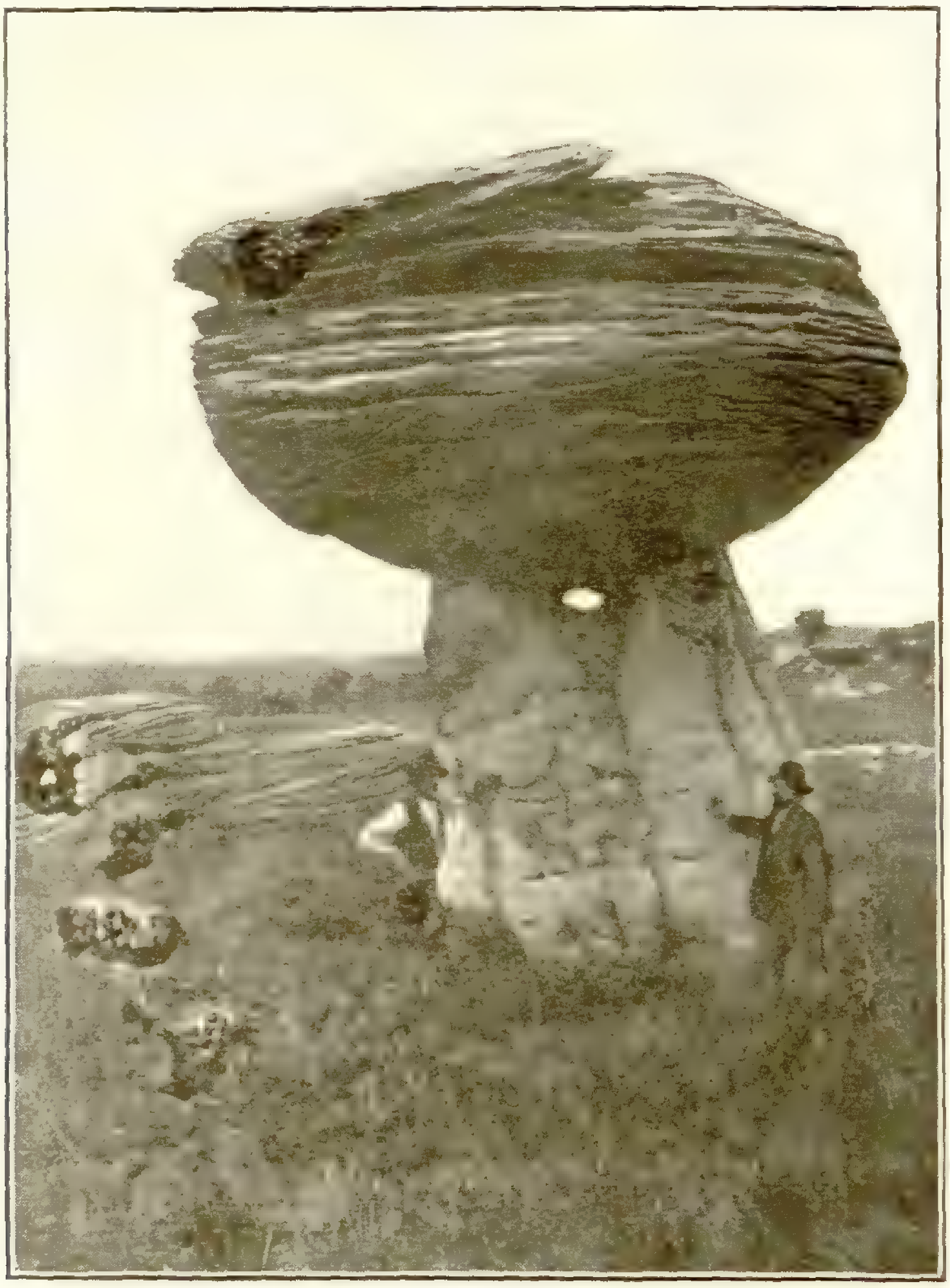
A. GRANITE MARKER OF SANTA FE TRAIL.

Blocks like this have been set at intervals along the old trail.



B. RESTORATION OF MAMMOTH.

Elephas imperator, a large elephant that was common in the southwestern United States in Pleistocene time. From a model in the American Museum of Natural History, New York City.



A. PULPIT ROCK, NEAR ALUM CREEK, SOUTH OF CARNEIRO, KANS.

A hard mass of Dakota sandstone which has resisted erosion better than the underlying softer bed that forms its pedestal.

B. PAWNEE ROCK, SOUTHWEST OF GREAT BEND, KANS.

A cliff of Dakota sandstone.

Just south of Barclay the ledge of Burlingame limestone is prominent to the west, and several small outliers of it cap knolls that stand east of the railway.

Barclay.

Elevation 1,171 feet.
Population 681.*
Kansas City 106 miles.

Reading.

Elevation 1,074 feet.
Population 289.
Kansas City 112 miles.

West of Reading the railway turns to the west and within 2 miles rises over the ledge of Burlingame limestone, then goes across 75 feet of the overlying Willard shale to the Emporia limestone, which begins on a divide half a mile beyond milepost 100. This bed is crossed again in the next divide to the southwest, and also on the down grade descending to Neosho River, which is reached near milepost 108. The Neosho is a stream of moderate size carrying the drainage of a wide area of east-central Kansas. In its north bank are bluffs of the Willard shale. South of the river is a long, wide flat extending 4 miles to and into Emporia. A mile east of the station at that place this line is joined by the Ottawa cut-off from Holliday.

Emporia.

Elevation 1,134 feet.
Population 9,058.
Kansas City 127 miles by Topeka (112 miles by Ottawa).

Emporia, the county seat of Lyon County, is an important business center for a wide area of farming country and is the site of the State Normal School, which has 2,600 students. Emporia is the type locality of the Emporia limestone, which here passes underground on its westward dip.

[The itinerary west of Emporia is continued on p. 22.]

HOLLIDAY TO EMPORIA BY WAY OF OTTAWA.[1]

Some of the trains on the Santa Fe Route now diverge from the old line at Holliday and take a more direct line nearly straight southwest by the Ottawa cut-off. This line runs over the plateau between Kansas and Osage rivers, then up the valley of the latter for some distance, and finally across the low but wide divide to Neosho River. On this line the railway crosses wide areas of shale and gradually rises from one limestone ledge to another in the great succession of rocks of later Carboniferous age that constitute the surface of eastern Kansas. The outcrops of these limestones extend from southwest to northeast across the country in lines of low cliffs, above some of which are bare rocky slopes of varying width. As the beds dip to the west, each bed of limestone passes in succession beneath the overlying shale, so that the beds which crop out in the bluffs near Kansas City lie several hundred feet below the surface at Emporia. These relations are shown in the cross section on sheet 1 (p. 14). On the other hand, the upper beds of limestone and shale, which crop out at the surface in the western part of the area, originally extended far to the east, but they have been removed by erosion down to the general level of the country

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[1] The mileposts on this line indicate distance from Kansas City.

There is a vast quantity of limestone in this region, part of it in beds too thin to be useful, but some of it in thick deposits and consisting of nearly pure calcium carbonate. This rock is utilized at Iola, Independence, and other places in Kansas and elsewhere for the manufacture of Portland cement.[1]

On leaving Holliday, the train ascends the valley of Mill Creek to its head at Olathe, a distance of 12½ miles and a rise of about 260 feet. This valley is excavated in the beds that constitute the bluffs at Kansas City and Argentine. Several beds of shale are exposed, and many ledges of limestone extend along the valley sides.

Olathe (o-lay′the, th as in thin; Shawnee for beautiful) is on the summit of the plateau which is traversed by the railway for many miles toward the southwest. This plateau is mostly covered by shale. At long intervals the railway descends into shallow valleys, most of them exposing ledges of underlying limestones.

Olathe.

Elevation 1,023 feet.
Population 3,272.
Kansas City 26 miles.

At Olathe the railway crosses the line of the Santa Fe Trail, which is described in the footnote on pages 17–18.

Gardner.

Elevation 1,065 feet.
Population 514.
Kansas City 34 miles.

Edgerton.

Elevation 966 feet.
Population 443.
Kansas City 40 miles.

Wellsville.

Elevation 1,043 feet.
Population 648.
Kansas City 46 miles.

Ottawa Junction.

Elevation 915 feet.
Kansas City 57 miles.

The trail lies a short distance north of the railway from Olathe through Gardner and Edgerton, but near Edgerton it diverges toward the west, going through Baldwin, which was formerly the well-known Palmyra stage station. A short distance west of Wellsville the railway track crosses a thin ledge of limestone and enters a broad area of shale. At Ottawa Junction (North Ottawa) the main line is crossed by a branch of the Santa Fe system which extends from Lawrence southward to Tulsa, Okla. A mile south of the junction is the town of Ottawa, which has a population of 7,650 and is the county seat of Franklin County. Ottawa is a locally important center and has several manufactories, most of them operated by water power from Osage River, which passes through the town. In borings at this place natural gas is obtained from sandstone at depths of 435, 665, 803, and 1,060 feet. Some years ago the skeleton of a mammoth was dug up on Main

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[1] Cement is made by burning a mixture of ground limestone and shale and grinding the resulting clinker to a very fine powder. In some places clay or loam is used instead of shale. Some limestones contain naturally a suitable admixture of the clay element for the manufacture of hydraulic cements, but the term Portland is generally applied only to cements produced by burning an artificial mixture, as described. Many of the thick beds of limestone exposed from Kansas City westward could be utilized for cement manufacture, but at present there would be difficulty in competing with the southern Kansas product owing to the advantage afforded by a natural-gas fuel supply to the plants located farther south. Moreover, the cement market appears to be amply supplied by plants now in operation at many places in the United States. The shale in the region from Kansas City westward could be utilized more extensively for tile, brick, and other similar products if fuel were cheaper or if the local demand were sufficient.

Street in Ottawa, and remains of others have been found in the vicinity. These large animals, which were closely similar in form to the elephant, were abundant in the United States thousands of years ago, together with various other species long extinct. A restoration of the principal variety of mammoth is shown in Plate II, *B* (p. 18). At Ottawa Junction, just south of the railway, is a factory where tiles, brick, etc., are manufactured from shale.

Pomona.

Elevation 923 feet.
Population 523.
Kansas City 68 miles.

West of Ottawa Junction the railway follows the low flats on the north side of the valley of the Osage (see sheet 2, p. 22) to a point 1½ miles west of Pomona, where it crosses that stream. It recrosses to the north bank just east of Quenemo. This river was named the Marais des Cygnes (swamp of the swans) by the early French trappers, from the fact that large numbers of swans frequented its marshy bottom lands during the winter.

Quenemo.

Elevation 941 feet.
Population 556.
Kansas City 72 miles.

At Quenemo the Santa Fe Railway is crossed by one of the lines of the Missouri Pacific system. This place was named for an Ottawa Indian who lived among the Sac and Fox tribes near Melvern. The surface rock of the valley in this region is shale, which is exposed in some of the cuts, notably in one 20 feet deep a short distance east of milepost 60. Most of the lower slopes of the valley are occupied by deposits of sand and gravel laid down by the river. Near Pomona the slopes on both sides of the valley are surmounted by low cliffs of Oread limestone in two or three prominent ledges. These beds, by their slight westward dip and the rise of the valley in the same direction, are finally brought to water level and crossed by the railway at Melvern.

Melvern.

Elevation 994 feet.
Population 505.
Kansas City 80 miles.

Olivet.

Elevation 1,136 feet.
Population 904.*
Kansas City 86 miles.

At Melvern the railway rises out of the Osage Valley and the railway cuts expose in close succession a number of limestones and at several places the intervening shales. At Ridgeton, west of Olivet, the railway regains the summit of the plateau at an elevation of 1,125 feet, or about 100 feet higher than in the region southwest of Olathe. On the summit there is a very instructive view to the northwest, showing a succession of steps formed by the outcrop of the thin but hard ledges of limestones, separated by long slopes of the intervening shales. This entire region is under cultivation, with fields of various crops and extensive pastures.

From Olivet to Neosho Rapids there is a continuous rolling plain of shale, interrupted, between mileposts 92 and 93, by a slope formed by the gently inclined upper surface (dip slope) of the Howard limestone, a relatively hard bed only about 1 foot thick.

Lebo.

Elevation 1,155 feet.
Population 560.
Kansas City 94 miles.

The coal bed lying below the Howard limestone has been worked at mines in the vicinity of Lebo. This coal is the same bed that is worked in the neighborhood of Scranton and Osage. (See pp. 17, 18.) The bed is 14 to 16 inches thick and is mined by stripping and tunneling.

Neosho Rapids.

Elevation 1,092 feet.
Population 256.
Kansas City 102 miles.

At Neosho Rapids the railway reaches the bank of Neosho River, a large stream flowing in a wide valley floored with thick beds of sand and loam it has itself deposited. Neosho is an Indian word meaning clear, cold water. This valley is followed as far as Emporia. Near milepost 104 the railway crosses Cottonwood River, which in this vicinity occupies the same wide flat as the Neosho and which empties into that stream a mile to the east. The thick accumulation of sand and loam deposited by these streams has reduced their slope and compelled them to follow very crooked courses. Near Emporia the Burlingame limestone, which slopes down from the east, crosses the valley of the two rivers, but it is covered by the alluvial deposits so that its precise location underground is not known. A mile east of Emporia the main line from Holliday by way of Topeka joins the Ottawa cut-off. Near this place the Santa Fe is crossed by a line of the Missouri, Kansas & Texas Railway, popularly known as "The Katy."

MAIN LINE WEST OF EMPORIA.

West of Emporia the railway passes over the flat bottom lands on the north side of Cottonwood River to Florence, a distance of 45 miles. The valley is wide near Emporia and as far west as Saffordville, and the shale slopes on the north and south rise gradually to plateaus capped by limestone.

Saffordville.

Elevation 1,142 feet.
Kansas City 139 miles.[1]

At Saffordville siding the Cottonwood Valley is much narrower and the limestone caps on the adjacent shale ridges are conspicuous. One limestone ledge is a short distance above the track; 30 to 40 feet higher, with shales intervening, is another limestone. These two limestone beds are exposed in many prominent ledges to the vicinity of Clements, a distance of 22 miles. The lower one (the Neva) is from 7 to 8 feet thick, and in the outcrop breaks out into large blocks with sharp angles and rough surface of chalky-white color. The Cottonwood limestone, the upper ledge, is one of the most continuous and best-marked formations of Carboniferous age in Kansas. It carries fossil mollusks of numerous species that are characteristic of the

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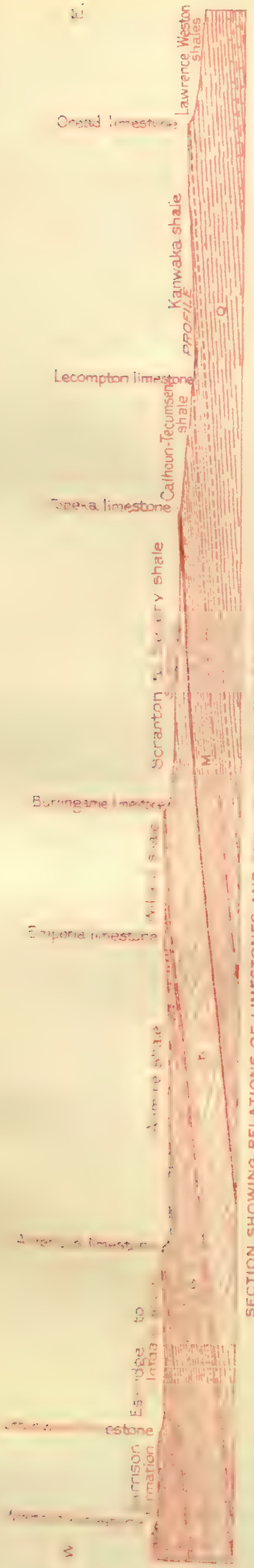
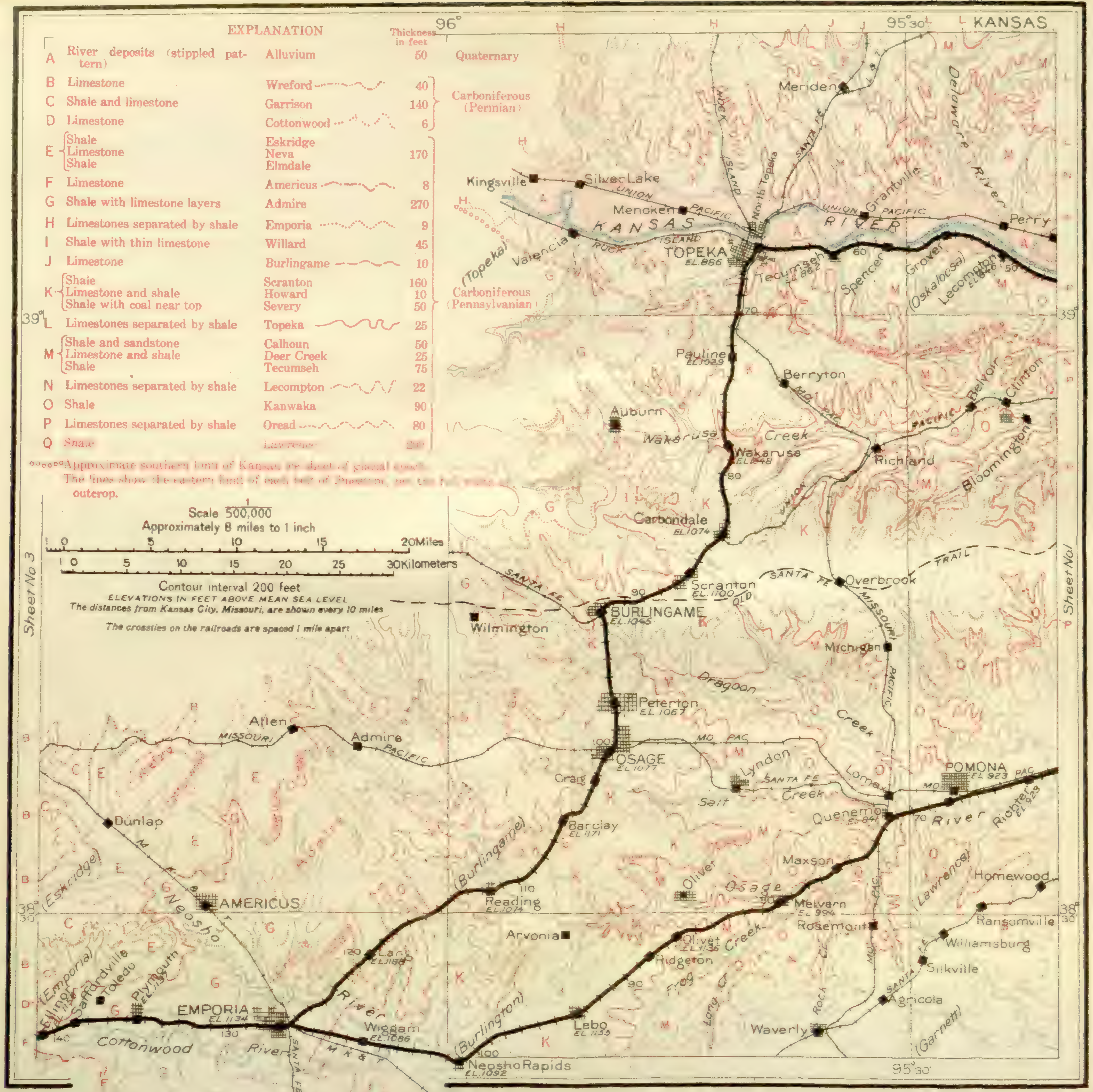
[1] Distances by way of Topeka are given for places west of Emporia. To get the distance traveled by way of the Ottawa cut-off 15 miles should be deducted.



SECTION SHOWING RELATIONS OF LIMESTONES AND SHALES ACROSS THE SOUTHERN PART OF THE AREA COVERED BY SHEET 2
VERTICAL SCALE GREATLY EXAGGERATED (2½ TIMES [illegible]), HAS EFFECT OF INCREASING APPARENT TILT OF BEDS



EXPLANATION

			Thickness in feet	
A	River deposits (stippled pattern)	Alluvium	50	Quaternary
B	Limestone	Wreford	40	Carboniferous (Permian)
C	Shale and limestone	Garrison	140	
D	Limestone	Cottonwood	6	
E	Shale Limestone Shale	Eskridge Neva Elmdale	170	
F	Limestone	Americus	8	
G	Shale with limestone layers	Admire	270	
H	Limestones separated by shale	Emporia	9	
I	Shale with thin limestone	Willard	45	
J	Limestone	Burlingame	10	Carboniferous (Pennsylvanian)
K	Shale Limestone and shale Shale with coal near top	Scranton Howard Severy	160 10 50	
L	Limestones separated by shale	Topeka	25	
M	Shale and sandstone Limestone and shale Shale	Calhoun Deer Creek Tecumseh	50 25 75	
N	Limestones separated by shale	Lecompton	22	
O	Shale	Kanwaka	90	
P	Limestones separated by shale	Oread	80	
Q	Shale	Lawrence	200	

ₒₒₒₒₒ Approximate southern limit of Kansas ice sheet of glacial epoch
The lines show the eastern limit of each belt of limestone, not the full width of outcrop.

Scale $\frac{1}{500,000}$
Approximately 8 miles to 1 inch

Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart

Permian series of the Carboniferous system. (See table on p. ii.) Its upper part consists largely of an aggregate of the fossil foraminifer *Fusulina cylindrica*, which the quarrymen call "rice" on account of its general resemblance to grains of wild rice. In the vicinity of Strong City, Clements, and Cottonwood Falls there are more than 20 large quarries in this limestone, constituting the largest quarrying industry in the State. The stone is of light color, uniform texture, and generally so free from joint planes that blocks of almost any desired length or breadth can be obtained. The two layers of which the formation consists in most places are only from 2 to 3 feet thick; locally it is in three layers. The Cottonwood stone is shipped great distances to places in Kansas and adjoining States.

Strong City.
Elevation 1,174 feet.
Population 762.
Kansas City 147 miles.

There is one limestone quarry of considerable size in the northern part of Strong City (see sheet 3, p. 26), north of the railway, and others a mile or two distant on the south side of the river, east of Cottonwood Falls. Strong City, named for W. B. Strong, a former president of the Santa Fe Railway Co., is on the north side of Cottonwood River, and the city of Cottonwood Falls is on the south bank of that stream, 1½ miles south of the railway at this point. At Strong City the Neva limestone is below the surface, and at milepost 133 the Cottonwood limestone also goes under. Within a short distance to the west, however, both of them are brought up again by doming of the beds (see glossary, p. 182), so that near Elmdale they are moderately high in the valley slopes. The underlying Eskridge shale also appears.

Elmdale.
Elevation 1,195 feet.
Population 253.
Kansas City 154 miles.

A boring recently made on the crest of the dome near Elmdale has found some natural gas, but the amount available has not been fully determined. Petroleum and gas occur in many places where the beds are domed, because structure of this kind offers a favorable condition for their accumulation. There are, however, numerous domes in which neither gas nor oil is found, so that this structure is not always evidence of their presence.

Clements.
Elevation 1,222 feet.
Kansas City 161 miles.

Clements is third in rank among the cattle-shipping towns of Kansas. A large number of cattle brought from various points west of this town are wintered here and fattened for market. A short distance beyond Clements is a small quarry in the Cottonwood limestone. In this part of the valley of Cottonwood River the slopes are terraced by the projection of hard layers of limestone as tabular shelves of considerable extent, each one terminating in a more or less prominent cliff, as shown in figure 4 (p. 24). In places there are three or four terraces or steps made by the succession of limestone beds, one above the other, separated by softer shales. All these beds dip to the west and are thus crossed in turn by the railway.[1]

In this valley there is a notable difference in character between the bottom lands, which have a deep, rich soil, and the adjoining slopes, where the soil is much thinner and is in many places interrupted by the rock outcrops. The valley lands are nearly all in a high state of cultivation, yielding a great variety of farm products. At many farms the traveler will see the round towers, mostly of concrete, known as silos, in which corn leaves and stalks and other similar green materials are kept green and moist to serve as winter fodder for stock.

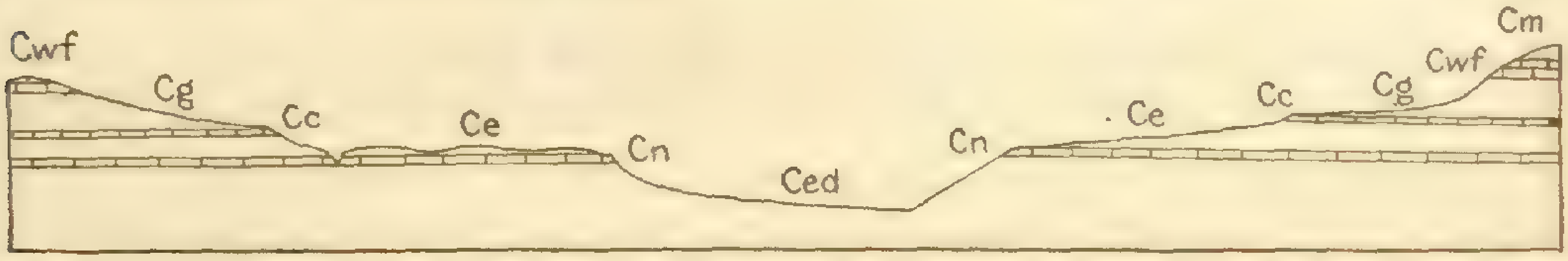


FIGURE 4.—Section across Cottonwood Valley southwest of Elmdale, Kans. Shows the terrace or steps produced by the limestone beds and the gentler slopes composed of shales. Cm, Matfield shale; Cwf, Wreford limestone; Cg, Garrison formation; Cc, Cottonwood limestone; Ce, Eskridge shale; Cn, Neva limestone; Ced, Elmdale formation.

Cedar Point.

Elevation 1,239 feet.
Kansas City 166 miles.

Between Clements and Cedar Point there are many shallow cuts in the shales overlying the Cottonwood limestone. At Cedar Point the Wreford limestone is crossed, but it is exposed only in a few ledges in the slopes north of the track.

A short distance east of Florence a large crusher north of the railroad is working the Florence flint and overlying Fort Riley limestone for road material.

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[1] The following list shows the beds included in the Permian series in central Kansas, also their character and average thickness near the Santa Fe Railway:

Formations of Permian age in central Kansas.

	Feet.
Sumner group:	
Wellington shale: Red and gray shales	350
Marion formation: Limestone and shale with gypsum and salt in upper part	160
Chase group:	
Winfield formation: Cherty limestone in part and shale	25
Doyle shale: Shale with thin beds of limestone	60
Fort Riley limestone: Buff limestone	40
Florence flint: Limestone, very cherty	20
Matfield shale: Shale and limestone	65
Wreford limestone: Buff cherty limestone	45
Garrison formation: Shales and limestone	145
Cottonwood limestone: Light-colored massive limestone	3

Florence, named for Miss Florence Crawford, of Topeka, is a junction point at which branches to the north and south leave the main line. Beyond Florence the railway leaves the Cottonwood Valley and ascends that of Doyle Creek, a tributary from the southwest. The strata lie nearly horizontal in this region, but dip slightly to the west, forming a continuation of the general monocline which exists throughout eastern Kansas.

Florence.

Elevation 1,262 feet.
Population 1,168.
Kansas City 172 miles.

West of Florence the traveler will note that pasture lands become more frequent and that cattle raising is an increasingly prominent industry. At many stations there are small stockyards with special gangways for loading cattle on cars for shipment east. There are also numerous fields of alfalfa, which is one of the most important forage crops in the West.[1] Some notably large fields of this plant may be seen just west of milepost 169.

At Peabody, which was named for F. H. Peabody, of Boston, large numbers of range cattle are received for fattening in the adjoining region. Here the Santa Fe line is crossed by the Chicago, Rock Island & Pacific Railway. West of Peabody the country is a wide, rolling upland, with numerous broad fields of grain, mostly wheat, interspersed with pastures. The few railway cuts show gray shales with some thin layers of limestone.

Peabody.

Elevation 1,351 feet.
Population 1,416.
Kansas City 184 miles.

Newton, named for the city in Massachusetts, is a minor railway center from which a branch line of the Santa Fe leads to Wichita and other places in southern Kansas and Oklahoma. It is also on one of the larger branches of the Missouri Pacific Railway. Years ago Newton had a very large cattle-shipping business, but most of this has long ago moved much farther west.

Newton.

Elevation 1,440 feet.
Population 7,862.
Kansas City 201 miles.

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[1] Alfalfa is generally called lucern in Europe. It is the oldest known plant to be cultivated exclusively for forage, as historians record its introduction into Greece from Persia as early as the fifth century before Christ. Its cultivation was attempted by the early colonists in America, but not until 1854, when a variety from Chile was introduced into California, did its development proceed rapidly. Alfalfa is peculiarly adapted to semiarid regions, for it does not require a moist climate and does not suffer from extreme heat or from relatively severe cold. It thrives best under irrigation, an occasional flooding being necessary for its growth. Besides being highly nutritive and palatable, alfalfa is, when well rooted, of rank growth, long lived, and hardy. It is said that in the semiarid regions there are alfalfa fields 25 years old. The best yield is obtained from the third to the seventh year. Its roots vary in length from 6 to 15 feet. Though alfalfa fields can be started in some places with a pound of seed (about 220,000 seeds) to the acre and good stands are often obtained with 5 pounds, about 15 pounds are used on irrigated lands. In some places alfalfa is cut three to five times a season and therefore produces a higher yield than any other forage plant in the western United States. Over 5,000,000 acres were in alfalfa in 1909. Kansas has the largest acreage, with Nebraska and Colorado next in order.

In this vicinity and for the next 25 miles to the west there are many settlements of thrifty Mennonites, who colonized here in 1874. The railways conducted a campaign of advertising in Europe and were instrumental in settling large areas of Kansas lands with colonies of Swedish, Welsh, Scotch, English, Germans, and Russians. The Mennonites were Germans of a particular creed who on account of their thrift and industry had been invited to settle in Russia, an invitation which they accepted. Some of their special privileges having been withdrawn, however, they emigrated to this country. They brought with them many plants and for a long time held their lands in community ownership. Each family brought over a bushel or more of Crimean wheat for seed, and from this seed was grown the first crop of Kansas hard winter wheat. At first this wheat seemed to be more difficult to mill and bake than the hard spring wheat, and even Kansas millers for some time either declined to receive hard winter wheat or paid a lower price for it than for softer wheats. In 1890 the prices of soft spring and soft winter wheats exceeded that of hard winter wheat by about 10 cents a bushel. In July, 1910, for the first time the price of hard winter wheat equaled that of the softer wheats.

About 4 miles west of Newton is an area of sands and gravels which fill a broad, moderately deep underground valley in shale, excavated by a large stream that long ago flowed across the region from the north and finally deposited the gravel and sand. This stream was probably an outlet for several rivers of northwestern Kansas, the Smoky Hill and probably also Solomon and Saline rivers, now branches of Kansas River. The width of the buried valley is about 20 miles in the region west of Newton, but a short distance south of the railway it merges into the valley of the Arkansas. Its western margin is well defined by the steep slopes of the land rising toward the northwest, but to the north and northeast are valleys since excavated to a lower level. The underground relations of the deposit have been explored by well borings, for the large amount of water which it yields is of great value, especially as there is but little water available in the shales of Permian age in the adjoining lands and in the floor under the basin. This resource has been an important factor in the development of Newton. When that town needed a city supply deep drilling soon demonstrated that little water was to be found underground in the city area, even at a great depth. On the advice of geologists tests were made in the edge of the buried valley a short distance west of the city, with most satisfactory results, and now this source yields a large volume of water which is piped to the city.

GEOLOGIC AND TOPOGRAPHIC MAP

OF THE

SANTA FE ROUTE

From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

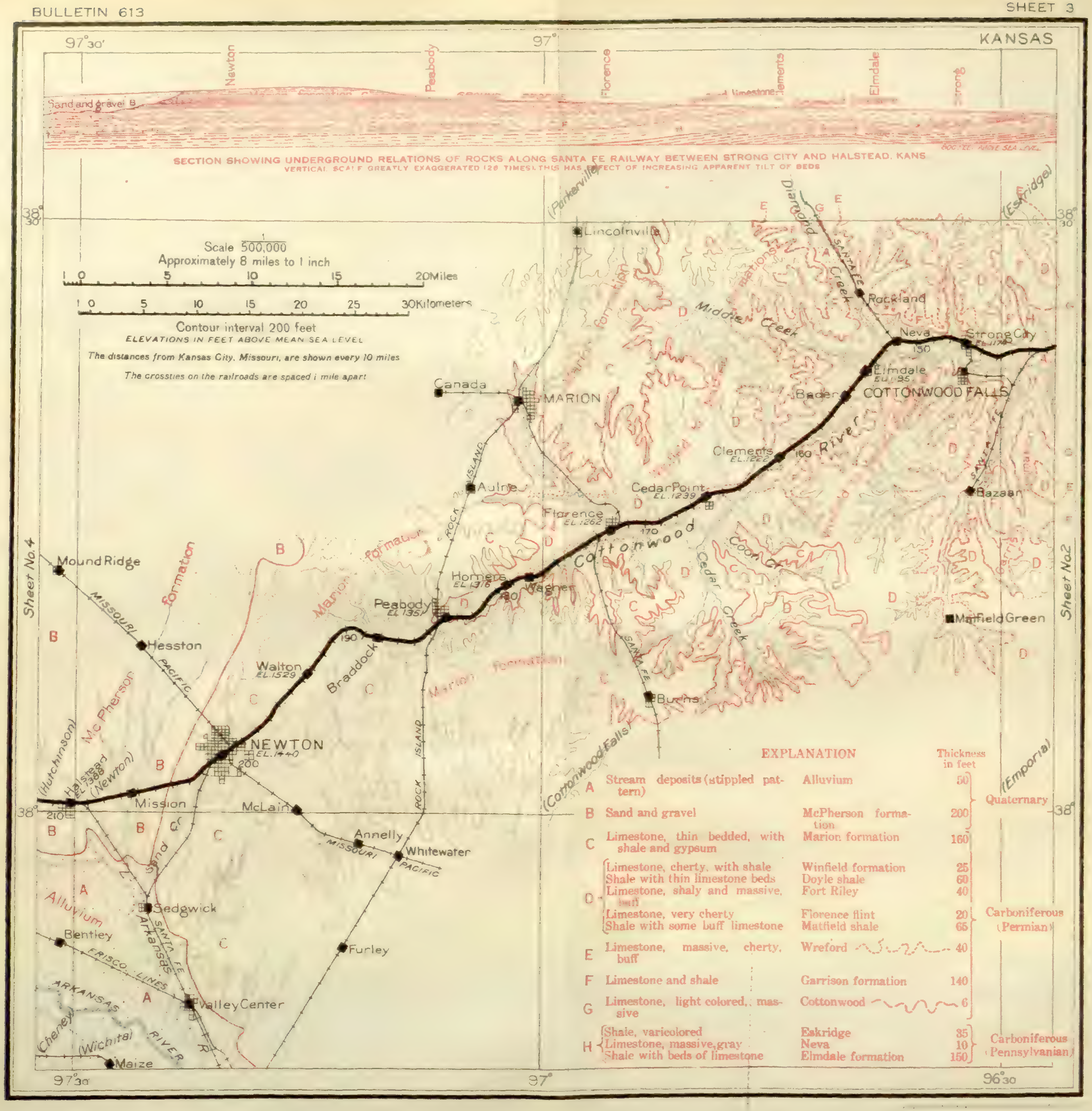
UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.



EXPLANATION

			Thickness in feet	
A	Stream deposits (stippled pattern)	Alluvium	50	Quaternary
B	Sand and gravel	McPherson formation	200	
C	Limestone, thin bedded, with shale and gypsum	Marion formation	160	Carboniferous (Permian)
D	Limestone, cherty, with shale	Winfield formation	25	
	Shale with thin limestone beds	Doyle shale	60	
	Limestone, shaly and massive, buff	Fort Riley	40	
	Limestone, very cherty	Florence flint	20	
	Shale with some buff limestone	Matfield shale	65	
E	Limestone, massive, cherty, buff	Wreford	40	
F	Limestone and shale	Garrison formation	140	
G	Limestone, light colored, massive	Cottonwood	6	
H	Shale, varicolored	Eskridge	35	Carboniferous (Pennsylvanian)
	Limestone, massive, gray	Neva	10	
	Shale with beds of limestone	Elmdale formation	150	

Halstead.
Elevation 1,388 feet.
Population 1,004.
Kansas City 210 miles.

From a point near Halstead a branch line runs to Sedgwick, connecting there with the line from Newton to Wichita and beyond.

Burrton.
Elevation 1,450 feet.
Population 689.
Kansas City 219 miles.

At Burrton (see sheet 4, p. 30) the Santa Fe line is crossed by a branch of the St. Louis & San Francisco Railroad (''Frisco'' line) running from Wichita to Ellsworth. South of Burrton are wide smooth plains extending to Arkansas River and forming part of the buried valley referred to above. A short distance north of Burrton is a range of sand dunes—low, irregular hills composed of loose sand which the wind has blown out of the flats along Arkansas River. These sand dunes extend northwestward for some distance past Hutchinson, not far north of the Santa Fe Railway. Burrton was named for I. T. Burr, a former vice president of the railway company.

Hutchinson.
Elevation 1,527 feet.
Population 16,364.
Kansas City 233 miles.

Hutchinson, the third largest city in Kansas, is attractively laid out, with wide streets, most of which are bordered by several rows of shade trees and extensive grassy parking. It was named for C. C. Hutchinson, its founder. The greater part of the city is on the north side of Arkansas River, but a portion known as South Hutchinson is on the south side. This river, called the Nepesta by the Spanish explorers, is one of the largest branches of the Mississippi, to which it carries an average of 200,000,000 cubic feet of water a day. It rises in the Rocky Mountains, in central Colorado. At Hutchinson the river valley is about 8 miles wide and is a broad expanse of nearly level land underlain by a thick body of sand and gravel that was deposited by the river and contains a large amount of water. Below this river deposit are shales containing thick deposits of salt. This mineral is extensively worked by several plants in Hutchinson, one of which is the largest in the world. They produce not only salt, but soda ash, caustic soda, and other chemicals manufactured from salt. The salt is obtained from borings about 800 feet deep, containing an outer casing down which water is forced and an inner casing up which this water, saturated with salt from the beds below, is pumped into tanks for evaporation. The production of salt at this place averages 2,000 barrels a day.

The salt occurs in beds about 380 feet thick (depth 430 to 810 feet) in the midst of red and gray shales of Permian age (see table, p. ii), where it was deposited long ago by the continued evaporation of extensive bodies of sea water. These great salt beds may reach far to the west and they underlie a large area extending southward to the Oklahoma line, but they appear to thin out toward the north and east. They are worked at several other places, notably at Lyons, 25 miles northwest of Hutchinson, where they are penetrated by a shaft 1,465 feet deep, which exposes more than 400 feet of salt, of which 275 feet (from 793 to 1,068 feet) is mostly in solid beds. There it is mined principally for the production of rock salt. The total annual production of salt in Kansas averages about 375,000 tons, valued at more than $800,000.

Hutchinson is in the center of the Kansas wheat belt and her flour mills have a daily product of 3,000 barrels. Electric power is extensively used in many mills and factories.

In the early days of settlement and travel the Hutchinson region contained many Indians, notably the Kiowas, who had come in from the north, and their allies, the Comanches, who controlled a large country south of Arkansas River. These Indians committed many massacres along the Santa Fe Trail, which crossed the country about 6 miles north of Hutchinson. This locality is believed to have been the scene of a decisive battle in 1778 between the resident Comanches and a band of Spaniards and Pueblo Indians under Gov. Anza, in which the Comanches were routed and their chief, Greenhorn, killed.

Most of the fast trains to the West take the cut-off which goes from Hutchinson almost due west to Kinsley, a distance of 84 miles, or about 15 miles less than the distance by the old main line along the river. On this cut-off the railway crosses to the south side of Arkansas River in the southwestern part of Hutchinson. Not far southeast of the bridge will be noted the tall stack of the largest salt works in the world.

Partridge.

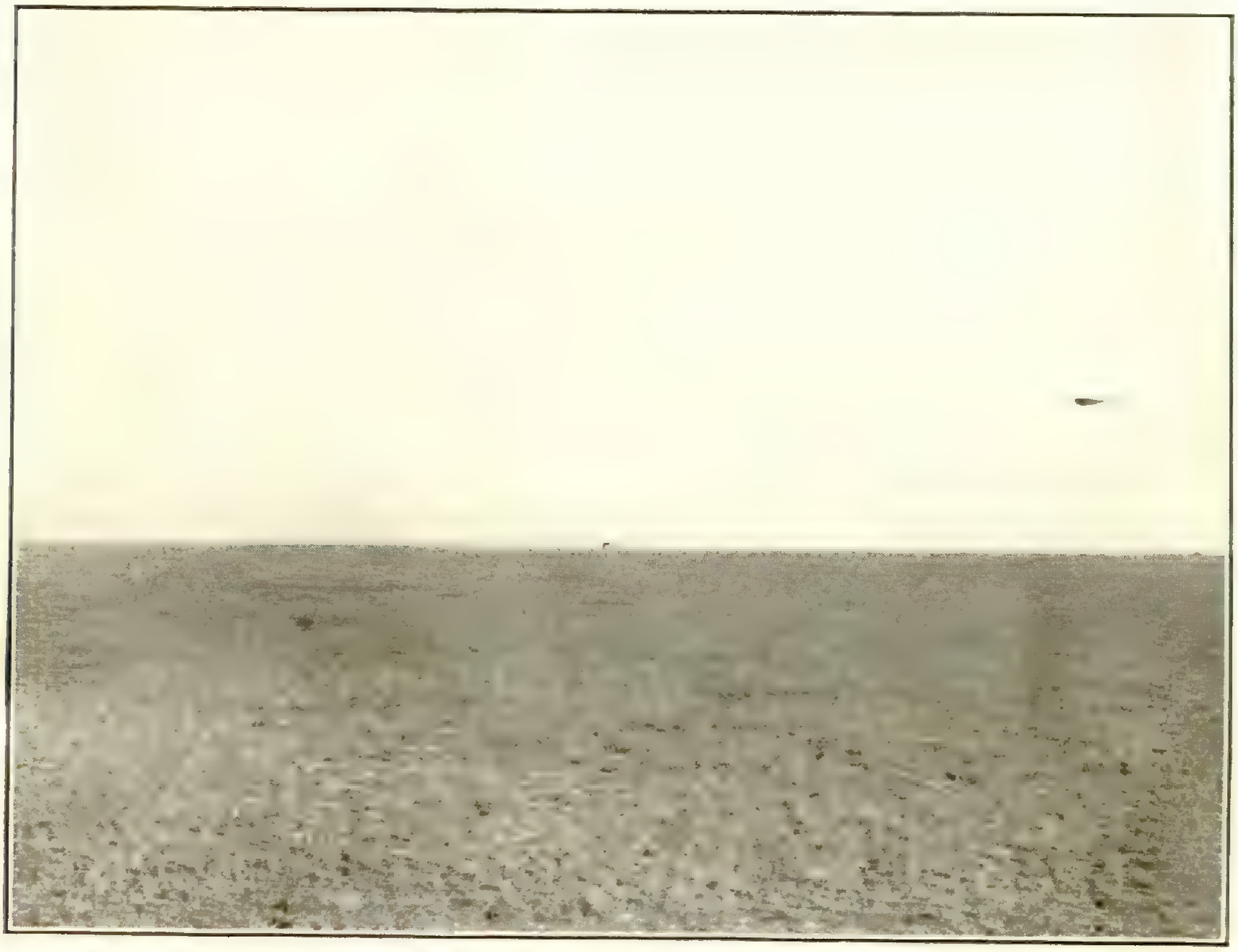
Elevation 1,605 feet.
Population 246.
Kansas City 244 miles.

Beyond the river the route goes nearly due southwest for a few miles to Partridge, rising by an almost imperceptible grade from the valley flat to a low plateau covered by sand and gravel which continues far to the west. This upland is covered by deposits laid down by Arkansas River or its predecessor in Tertiary time. It is a great plain, most of which is occupied by broad fields of grain, for it is one of the most extensive wheat districts in the country. The soil is particularly favorable in composition, and in most years the rainfall is sufficient to give large crops, but occasionally there is a year too dry to yield satisfactory returns.

Abbyville.

Elevation 1,651 feet.
Kansas City 250 miles.

West of Abbyville is a region of sand hills. The dunes are mostly low and covered with soil, which bears crops of wheat or other grains. They are old dunes and, except for a small amount of sand that blows during the windy season, they are not advancing materially. The railway cuts are shallow and show either the loose dune sand or the brownish compact sand of Tertiary age, which forms the surface of the plain.

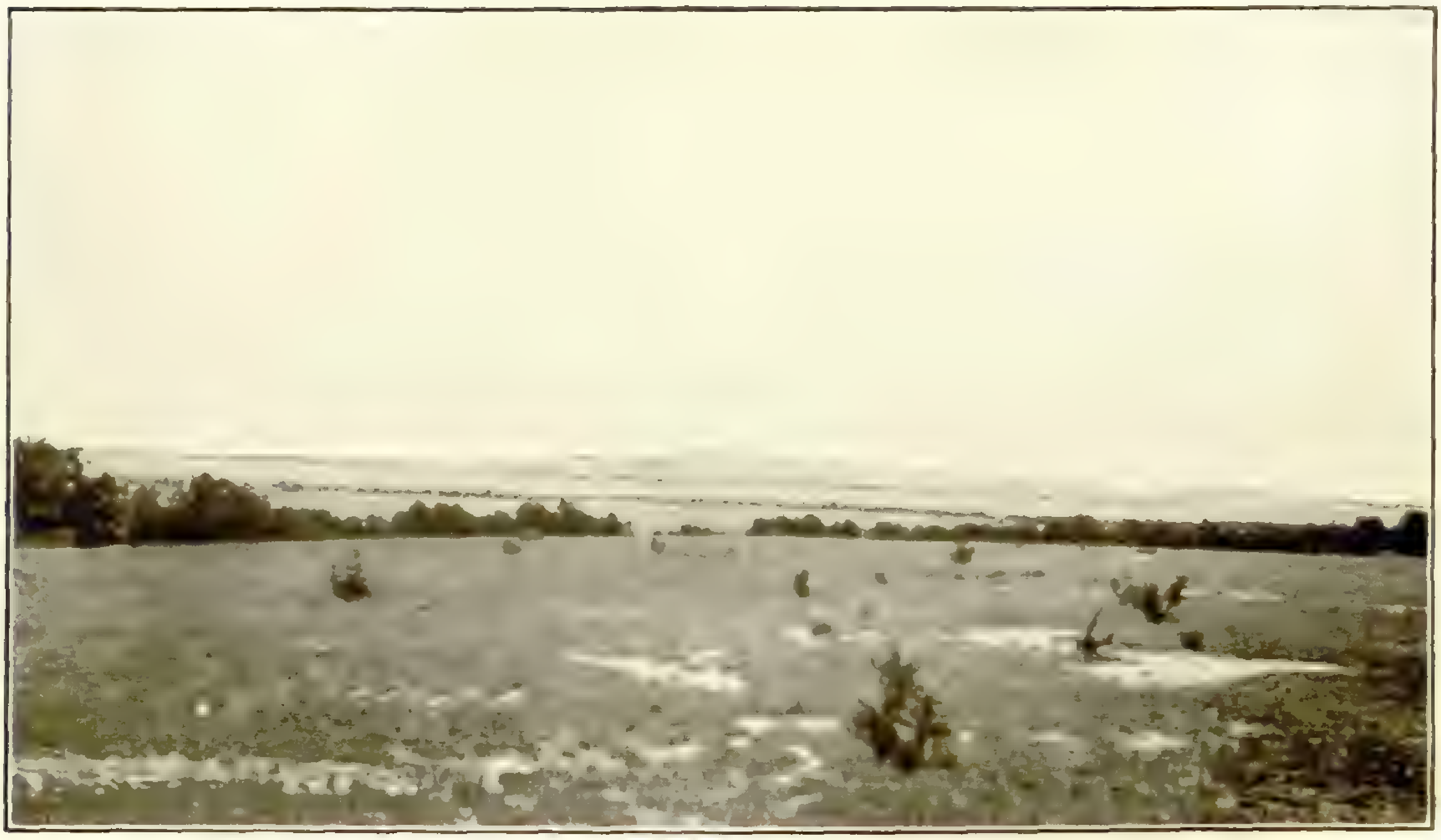


A. THE GREAT PLAINS OF WESTERN KANSAS.

Smooth and almost level, but sloping upward to the west.

B. BUFFALO—ONE OF THE FEW SURVIVORS.

Photograph by E. L. Bristol, Cheyenne, Wyo.



A. MESAS OF TIMPAS LIMESTONE, BLOOM-THATCHER REGION, COLO.

Below the limestone caps are slopes of shale (Carlile) to a wooded bench of Greenhorn limestone. Dakota sandstone forms foreground.

B. TYLOSAURUS.

A mososaur, or great marine lizard, from the chalk beds of the Niobrara formation in western Kansas. Restoration by C. R. Knight.

Stafford.
Elevation 1,858 feet.
Population 1,927.
Kansas City 272 miles.

At Stafford, named for Lewis Stafford, a captain in the First Kansas Regiment, the Santa Fe line is crossed by a branch of the Missouri Pacific Railway. This region is typical of the Great Plains,[1] its smooth surface being apparently level but rising gently toward the west. The surface formation is moderately compact sand, in places containing concretions or streaks of calcium carbonate. The thickness of this deposit is not known, but it is probably about 100 feet. It is supposed to lie on the thin eastern edge of the Dakota sandstone.

Originally the prairies of the central Kansas region were almost treeless except for the cottonwoods along some of the streams, but settlers have planted trees around their houses and along many of their road hedges, so that now some trees appear in every view. It is believed by some that the presence of vegetation of this kind has increased the rainfall and diminished the number and violence of tornadoes, but meteorologists deny that these changes have had any material effect.

A few miles northeast of Stafford are marshes caused by salt springs. The salt water was used extensively in the early days for curing meat, and in 1878 a small salt works was erected to extract the salt for sale in the surrounding country.

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[1] The Great Plains are smooth treeless slopes that extend eastward from the foot of the Rocky Mountains into central Kansas as well as into adjoining States on the north and south. Their western margin has an altitude of almost 5,000 feet near the Rocky Mountains, from which they make a practically continuous descent to an altitude of 2,000 to 2,200 feet in central Kansas, where they merge into the rolling prairies that have been described on previous pages. The plains are trenched by the relatively shallow valleys of many rivers and creeks flowing to the east, but extensive areas of the remarkably smooth tabular surfaces remain between these valleys. One of these is shown in Plate IV, *A*.

The major part of the Great Plains is covered by sands, gravels, and loams of late Tertiary age, varying in thickness from 50 to 200 feet in greater part and in general lying on a relatively smooth surface of the older rocks. The materials were brought from the Rocky Mountain region by streams which ran in various courses across the region, sometimes cutting valleys but mostly depositing sediments. The time was one of relatively arid conditions, probably in general similar to the present, the streams bringing out of the mountains a larger amount of sediment than they could carry through to the great rivers on the east. The process was long continued, and it is likely also that at times the stream grades were somewhat less than they are at present, so that the deposits were not to any great extent deeply trenched by small creeks, as they are now. It is known from the fossil bones found in the deposits that the region was inhabited by numerous land animals of a sort very different from those of the present era. There were rhinoceroses, camels, three-toed horses, elephants and bisons of peculiar types, as well as a great many species of smaller animals. At certain places in the region large numbers of bones of these strange animals have been found and dug out, and many of these bones are now carefully preserved in museums.

West of Stafford, notably at milepost 261, the railway crosses a small belt of sand dunes, and near milepost 262 there are bare areas from which the sand is being blown by the wind.

St. John.

Elevation 1,908 feet.
Population 1,785.
Kansas City 282 miles.

St. John (see sheet 5, p. 36) is on the great smooth plain, in the midst of grain fields. It was named for John P. St. John, governor of Kansas from 1879 to 1883 and a famous advocate of prohibition.

Macksville.

Elevation 2,025 feet.
Population 626.
Kansas City 293 miles.

The region about Macksville is a gently rolling plain with very low sand hills, which continue to Belpre and beyond Lewis. Macksville was named for George Mack, the first postmaster in Stafford County.

Belpre.

Elevation 2,082 feet.
Population 485.
Kansas City 300 miles.

A large sign south of Belpre (bel-pray′) station contains the statement that $1,250,000 worth of farm products were shipped from that place in 1913. Belpre is the center of a prosperous region in which wheat and other grains are raised. The name is French for beautiful prairie.

Lewis.

Elevation 2,142 feet.
Population 557.
Kansas City 309 miles.

Lewis is near the eastern edge of a pronounced belt of sand hills, which extends along the east side of Arkansas River for many miles. These dunes become prominent a short distance west of Omar siding, where the railway passes through 20-foot cuts in the loose, cross-bedded dune sand. Here the dune surface is too rugged for much farming, but there are scattered wheat fields in some of the depressions between the dunes. About 3 miles west of Omar Arkansas River is crossed, and a short distance beyond is Kinsley. Here the Hutchinson branch or cut-off joins the old main line from Hutchinson by way of Great Bend.

[The itinerary west of Kinsley is continued on p. 35.]

HUTCHINSON TO KINSLEY BY WAY OF GREAT BEND.

From Hutchinson (see sheet 4, p. 30) to Kinsley the old main line of the Santa Fe Railway follows the north bank of Arkansas River, but at most places the tracks are a mile or two from the stream. For the entire distance the route lies along the wide flat or alluvial bottom land, which ranges from 5 to 8 miles in width. From Hutchinson to Great Bend the course is northwest, but from Great Bend to Kinsley the course is southwest, owing to a remarkable bend in the valley.

The flat consists of smooth bottom lands elevated but slightly above the river, and in their lower parts subject to overflow during the occasional freshets. These lands are formed by a thick body of sand and gravel deposited by the river and lying in a wide, shallow

GEOLOGIC AND TOPOGRAPHIC MAP
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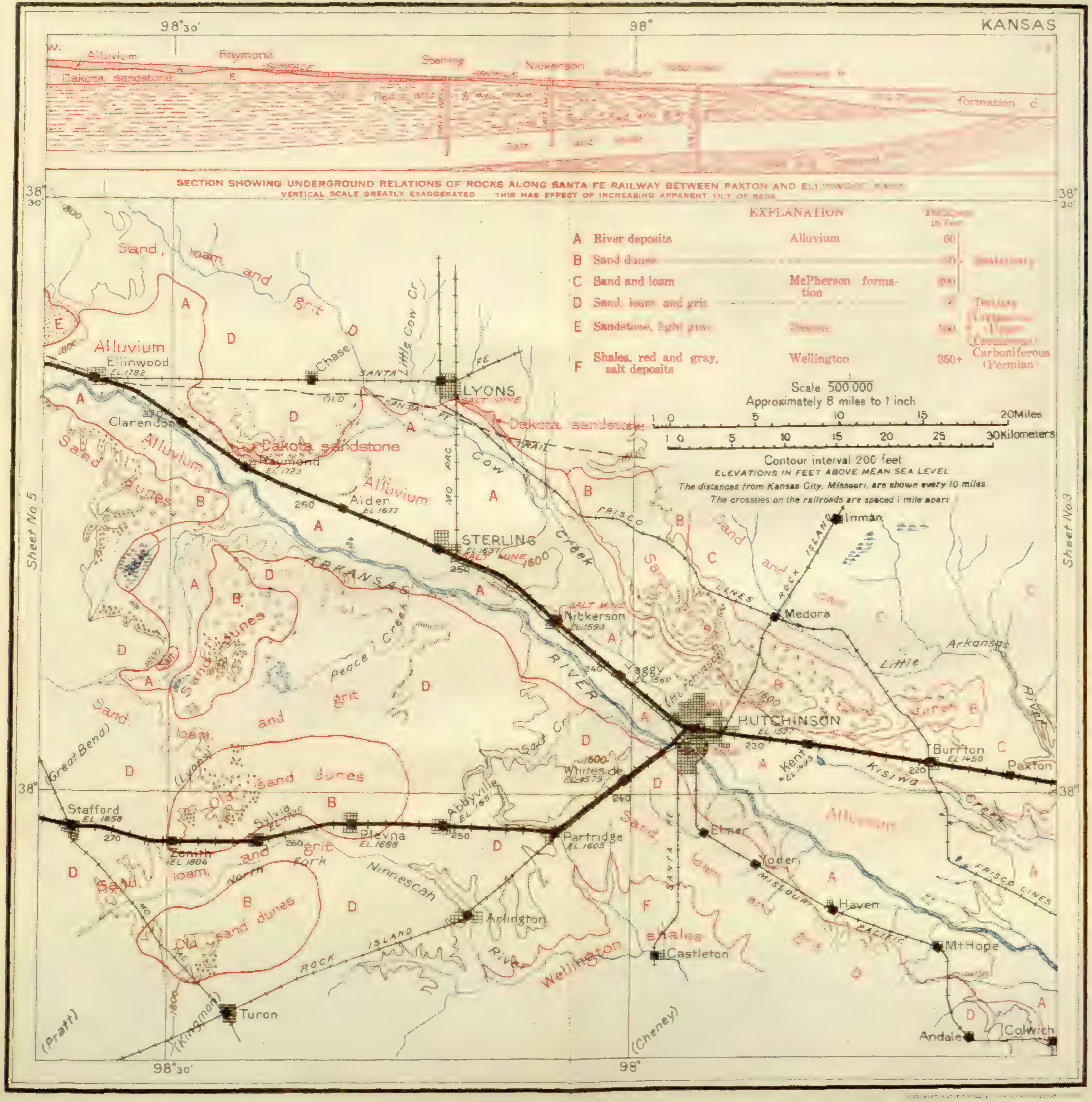
Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist R. B. Marshall, Chief Geographer
1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.



trough which this stream cut in the underlying shales and sandstones at an earlier stage in its development. The river belongs to the class of large streams in the west which have excavated wide, shallow valleys across the country and now, owing to their heavily loaded condition at times of freshets, are gradually filling them again. The result is a wide level plain, floored with river-borne materials, through which the stream meanders with irregular course and very slight declivity. In the Arkansas Valley from Kinsley, where the altitude is 2,160 feet, to the bridge at Hutchinson, where the altitude is 1,500 feet, the fall is 660 feet. As the distance between these points is somewhat less than 100 miles the rate of fall is only about 6.6 feet to the mile, which is normal for a river of moderate size.

From Hutchinson to Sterling the level alluvial flat is an almost continuous wheat field. A large amount of broom corn is also raised. About 5 miles northeast the railway is paralleled by the low ridge of sand dunes mentioned on page 27.

Nickerson, named for Thomas Nickerson, an official of the Atchison, Topeka & Santa Fe Railway Co., is on the broad flat about a mile from the river bank. Sterling, the next station, is about 2 miles north of the river. In the eastern part of Sterling, north of the railway, a large salt refinery is obtaining salt by forcing water down a pipe sunk deep into the salt-bearing strata and pumping out the saturated solution, as in the plants at Hutchinson. Here a line of the Missouri Pacific Railway, which runs parallel to the Santa Fe from Hutchinson, crosses it and goes northward to Lyons and beyond.

Nickerson.

Elevation 1,593 feet.
Population 1,195.
Kansas City 244 miles.

Sterling.

Elevation 1,637 feet.
Population 2,133.
Kansas City 252 miles.

In the vicinity of Alden the valley flat is nearly 15 miles wide, extending north almost to Lyons. Near Raymond, however, a ridge of the upland approaches the river from the north and narrows the valley greatly. At the base of this ridge appear brown ledges of the Dakota sandstone which extend along the foot of the hills not far north of the track to a point some distance beyond Raymond. This sandstone is a very porous rock and wherever it occurs underground is an important water bearer that yields valuable supplies in thousands of wells in the Middle West. The sandstone is near the surface in a wide area along the Arkansas Valley from the vicinity of Sterling to Ford, but owing to the covering of sand and gravel outcrops of the sandstone are rare. Some of those which occur have fantastic forms such as that shown in Plate III, *A* (p. 19).

Alden.

Elevation 1,677 feet.
Kansas City 258 miles.

Raymond.

Elevation 1,723 feet.
Population 702.*
Kansas City 264 miles.

In this region the beds lie nearly level, for the gentle westward dips which exist in the region east of Hutchinson gradually give place in this portion of central Kansas to equally low eastward dips, which prevail throughout the western part of the State and beyond to the Rocky Mountain uplift. The shallow trough resulting from this change of dip crosses central Kansas in the vicinity of Great Bend, and it is not improbable that this structural condition was the cause of the very notable deflection of the Arkansas Valley to the northward in the region between Dodge and Great Bend.

From Raymond to Ellinwood the Valley of the Arkansas widens again, especially the portion which lies south of the river, where, however, there is a broad bordering zone of low hills built of sand blown from the river bed.

Ellinwood.

Elevation 1,782 feet.
Population 976.
Kansas City 275 miles.

Ellinwood is in the center of a wide area of fields of wheat and other grains and a large amount of these products are shipped from its station. The town was built many years before the coming of the railway in 1871, for here the Santa Fe Trail reached the Arkansas Valley.

Great Bend.

Elevation 1,843 feet.
Population 4,622.
Kansas City 285 miles.

Great Bend (see sheet 5, p. 36) is the seat of Barton County, the junction with a branch of the Santa Fe running to Scott City, and the terminus of a branch of the Missouri Pacific Railway from Hoisington. It takes its name from its situation on the long curve in the river from northeast to east and finally to the southeast at Ellinwood. The town was begun in 1870 and is built on the smooth river flat, which is very wide here owing to the confluence of the Walnut Creek valley with that of the Arkansas. Water power from Walnut Creek is utilized in Great Bend for extensive flour mills, grain elevators, factories, and salt works.

Great Bend is in the country formerly occupied by the Wichita Indians. Near by was the mythical city of Quivira (kee-vee'ra), to which Coronado journeyed in 1541, expecting to obtain a great store of treasures. He was disappointed in finding instead of a "city" scattered Indian villages consisting of small groups of conical huts of poles thatched with grass and containing no valuables whatever. To the north of Quivira was the land of the Pawnees, who had permanent villages. They made frequent attacks upon individuals and caravans and treated their captives with appalling cruelty.

The old Santa Fe Trail passes through the courthouse square of Great Bend, and a short distance east of the city the railway crosses Walnut Creek at the place of the old ford. Here was Fort Zarah, the ruins of which are visible a short distance north of the tracks. The place is marked by a stone cannon. This fort, established by Gen. S. R. Curtis in 1864 and named for his son, was one of the line of military posts placed at intervals along the Santa Fe Trail to protect the traveler. It was garrisoned with soldiers who escorted wagon trains through the district west of Great Bend, where the Indians were especially dangerous. Long before the fort was established the place was noted for massacres and Indian wars, mainly because of a grove which afforded the Indians concealment. Moreover, it was on one of the lines of travel always taken by the buffaloes in their annual migration and therefore was visited by the Indians on their summer hunting trips.

The area from Great Bend westward for a hundred miles or so was a famous hunting ground for all the plains tribes, as its excellent pasturage made it the home of vast herds of buffaloes, besides plenty of antelopes and deer. For this reason it was the scene of innumerable conflicts between the tribes, none of which could maintain permanent control of it. The big game has been gone for many years, and now only occasional jack rabbits, squirrels, and nocturnal animals remain.

Arkansas River from Great Bend to Pueblo, Colo., was followed by Lieut. Zebulon Pike on the trip during which he saw for the first time the peak of the Rocky Mountains that bears his name.

In the slopes north of Great Bend and in the stream banks at intervals up Walnut Creek there are exposures of the brown ledges of Dakota sandstone, a formation in which are excavated the valleys of this general region. In 1887 a boring was made 3 miles north of Great Bend, in which the great salt bed already mentioned was penetrated for 163 feet, proving its extension in this direction from Hutchinson and Lyons. At a depth of 744 feet a flow of water was found which ran out of the casing to a height of 30 feet above the ground.

Pawnee Rock.

Elevation 1,941 feet.
Population 458.
Kansas City 298 miles

Near milepost 281, which is about 10 miles southwest of Great Bend, Pawnee Rock is discernible in the distance, and at milepost 282 it is plainly in view, rising on the north side of the valley a short distance north of Pawnee Rock station. The rock is a high southward-facing cliff of Dakota sandstone, projecting as a rocky promontory from the broad ridge that forms the north side of the valley. Its present appearance is shown in Plate III, *B* (p. 19). The elements and the hand of man have made great changes in its size and appearance since the days when the Santa Fe Trail passed along its base. Here were many encounters between the savages and the whites, and also between hostile bands of Indians, for the place is noted not only in pioneer history but in Indian traditions as well. Names and initials of many travelers, from the early trappers and the "forty-niners" to the later Army detachments, have been scratched on the smooth faces of the ledges.

Pawnee Rock was named from the Indian tribe which roamed over the neighboring plains, menacing the life and property of almost every passer-by on the trail, as they had menaced the Spaniards for two centuries. The name Pawnee is supposed to signify horn and to have been applied to the tribe on account of a curious custom of plucking out beard and eyebrows and shaving the head, except a narrow ridge of hair from forehead to scalp lock; this remnant was stiffened with fat and paint so that it stood erect and curved like a horn.

Half a mile beyond milepost 287, or 4½ miles southwest of Pawnee Rock, there may be seen west of the track a granite monument, which is one of the numerous markers of the line of the Santa Fe Trail.

Larned is at the mouth of Pawnee River, which enters the Arkansas on the southern edge of the town. On the north bank of the Pawnee, west of the railway, there are several quarries in the Dakota sandstone which are plainly visible from the vicinity of milepost 292 and beyond. The rock is of a light-brownish color and occurs in massive beds, about 40 feet in all, exposed in several quarries. It has been used to some extent as a building stone and when fresh is easily sawed or chiseled.

Larned.
Elevation 1,995 feet.
Population 2,911.
Kansas City 307 miles.

The railway bridge crosses Pawnee River at the old ford of the Santa Fe Trail. Owing to a twist in the course of the stream the crossing was difficult. Many a thrilling skirmish or frightful massacre has occurred here, and in 1870 a great battle was fought at this place between Cheyennes and Arapahoes. This locality should not be confounded with Fort Larned, which lies 6½ miles due west of it.

On the old trail there was not a bridge from end to end and all the stream crossings were fords, which at times of high water became impassable. When the Army of the West crossed Pawnee River on its long march to take Santa Fe in 1848 that stream was in flood and could not be forded. However, trunks of trees were thrown across and over these the men clambered, carrying their baggage, tents, and supplies, while the horses swam across and the empty wagon boxes were pulled over with ropes.

In the vicinity of Larned the conditions on the two sides of the Arkansas present a striking contrast. On the southeast side there is a wide belt of sand hills composed of sand blown out of the river bed by the prevailing strong northwest winds. These hills are too rough and bare for agriculture. On the northwest side of the river, where the railway is built, there are bottom lands with rich, deep soil, usually yielding large crops of grain.

Not far northeast of Garfield a ledge of Dakota sandstone rises above the river flat and is cut by the railway for a short distance.

Garfield.

Elevation 2,069 feet.
Population 333.
Kansas City 318 miles.

Near Garfield the Arkansas Valley is much narrower than at most other places, for a ridge of the upland encroaches from the northwest and the sand dunes on the southeast side of the river rise rapidly to the broad plain which borders the valley on that side. Near Kinsley the ridge on the north side of the valley trends somewhat northward and the flat widens to about 4 miles.

Kinsley.

Elevation 2,164 feet.
Population 1,547.
Kansas City 332 miles.[1]

At Kinsley, named for W. E. W. Kinsley, of Boston, the old main line of the Santa Fe by way of Great Bend is joined by the cut-off or Hutchinson branch, described on pages 28–30. West of Kinsley the railway continues its nearly direct course west, diverging from the valley of the Arkansas, and thus avoiding the southward bend of the river. The ascent to the surface of the Great Plains[2] is so gradual as to be barely noticeable, for the valley slopes west of Kinsley are very gentle.

Offerle.

Elevation 2,263 feet.
Kansas City 340 miles.

At milepost 324, about a mile east of Offerle, is an 8-foot cut showing exposures of brown loam with streaks of gravel, apparently a part of the deposit of Tertiary age which covers the Great Plains. The eastern edge of this loam appears to pass downward toward the east under the higher terrace deposits of the Arkansas Valley, which are of later age. Probably both lie on the Dakota sandstone. A short distance beyond milepost 329 are other small exposures of the gravelly loam in shallow railway cuts.

Bellefont.

Elevation 2,347 feet.
Kansas City 346 miles.

West of Bellefont, between mileposts 331 and 332, and for half a mile west from milepost 332, are cuts in the brown sand containing white calcium carbonate concretions. Westward of these cuts the line gradually ascends on a very smooth surface typical of the Great Plains.

Spearville.

Elevation 2,451 feet.
Population 576.
Kansas City 351 miles.

Wright.

Elevation 2,516 feet.
Kansas City 360 miles.

Spearville and Wright (see sheet 6, p. 40) are on the plain, which reaches an altitude of 2,570 feet in the summit a short distance west of Wright. Beyond this point there is a down grade into the valley of the Arkansas, and the train passes through extensive cuts, beginning near milepost 347. Brown loams and fine sands of Tertiary age are exposed in these cuts, in some places to a depth of 10 feet. South of the railway, at a point half a mile beyond milepost 349, there are scattered exposures of a bed of white limestone a few feet thick, which underlies the Tertiary deposits in a wide area in this vicinity. The river deposits in the valley of the Arkansas abut against the lower portion of this limestone at milepost 349 and for some distance west.[1]

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[1] The distances given in the side notes are those by the old main line. To get the distance traveled by way of the Ottawa and Hutchinson cut-offs 30 miles should be deducted from the figures given for Kinsley and stations beyond; the distance by way of Topeka and the Hutchinson branch can be ascertained by deducting 15 miles.

[2] The Great Plains, a part of which is crossed on the way to Dodge, are described in the footnote on page 29.

In approaching Dodge the railway again comes near the Arkansas River, the north bank of which is followed from Dodge westward. The wide bottom lands near the river are occupied by fields of grain and orchards. In this vicinity Coronado in 1541 reached this river, which he called the River of St. Peter and St. Paul. On the river, 5 miles east of Dodge, is old Fort Dodge, now a soldiers' home, but formerly an important frontier garrison on the Santa Fe Trail. Some of the old buildings remaining were headquarters of Gen. Custer and Gen. Miles in the days when Col. W. F. Cody (Buffalo Bill) and other famous scouts were aiding the United States Army to protect travelers and to subdue the Indians. The Indians were troublesome in this part of the West for some years after the Civil War was over, and there were massacres in western Kansas as late as 1874.

Dodge, formerly known as Dodge City, was named for Gen. Henry Dodge, governor of Wisconsin Territory. It is now a commercial center for a wide adjacent region containing numerous farms and cattle ranches. This was a famous frontier town, the center of important lines of freighting, and headquarters of the cattle business, which attained its maximum in 1884, when herds aggregating 800,000 cattle, in charge of 3,000 men, passed through Dodge from Texas on the way north. Much hunting was done in this region, for there were immense herds of buffaloes[2] and other game throughout central Kansas. (See Pl. IV, *B*, p. 28.)

Dodge.
Elevation 2,478 feet.
Population 3,214.
Kansas City 368 miles.

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[1] In the descent into Duck Creek, a branch of Sawlog Creek, 7 miles northeast of Dodge, there are very instructive exposures of this basal limestone, 10 to 15 feet thick, pebbly at the base, lying on 20 feet of Greenhorn limestone. The two (*b*, *c* in fig. 5) form a white cliff that rims the valley to the north. The Greenhorn limestone includes beds of chalky limestone as much as 6 inches thick, and some layers of it are filled with impressions of a fossil shell (*Inoceramus labiatus*) characteristic of this formation. The relations of the rocks here are shown in figure 5.

[2] Large circular pits, called buffalo wallows, are common on the plains and are puzzling to the average traveler. They were started by buffaloes either in wet spots or at places where there is salt or alkali, which the animals lick. The tramping of the hoofs of the heavy animals wears the sod thin, and then the wind soon blows out a cavity, or if water collects in it the mud is carried out in large

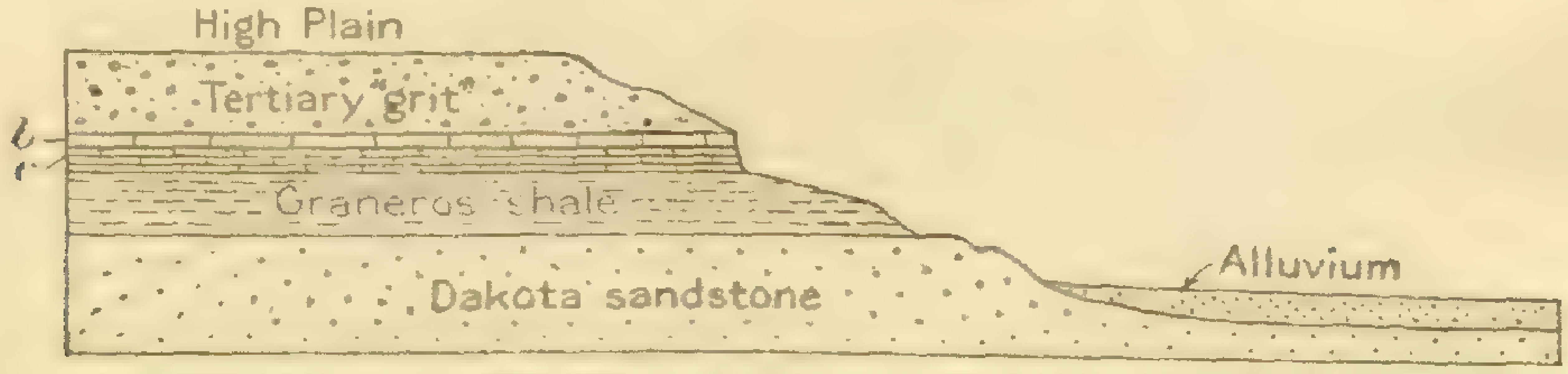

FIGURE 5.—Section of rocks in Sawlog Valley, northeast of Dodge, Kans.

GEOLOGIC AND TOPOGRAPHIC MAP
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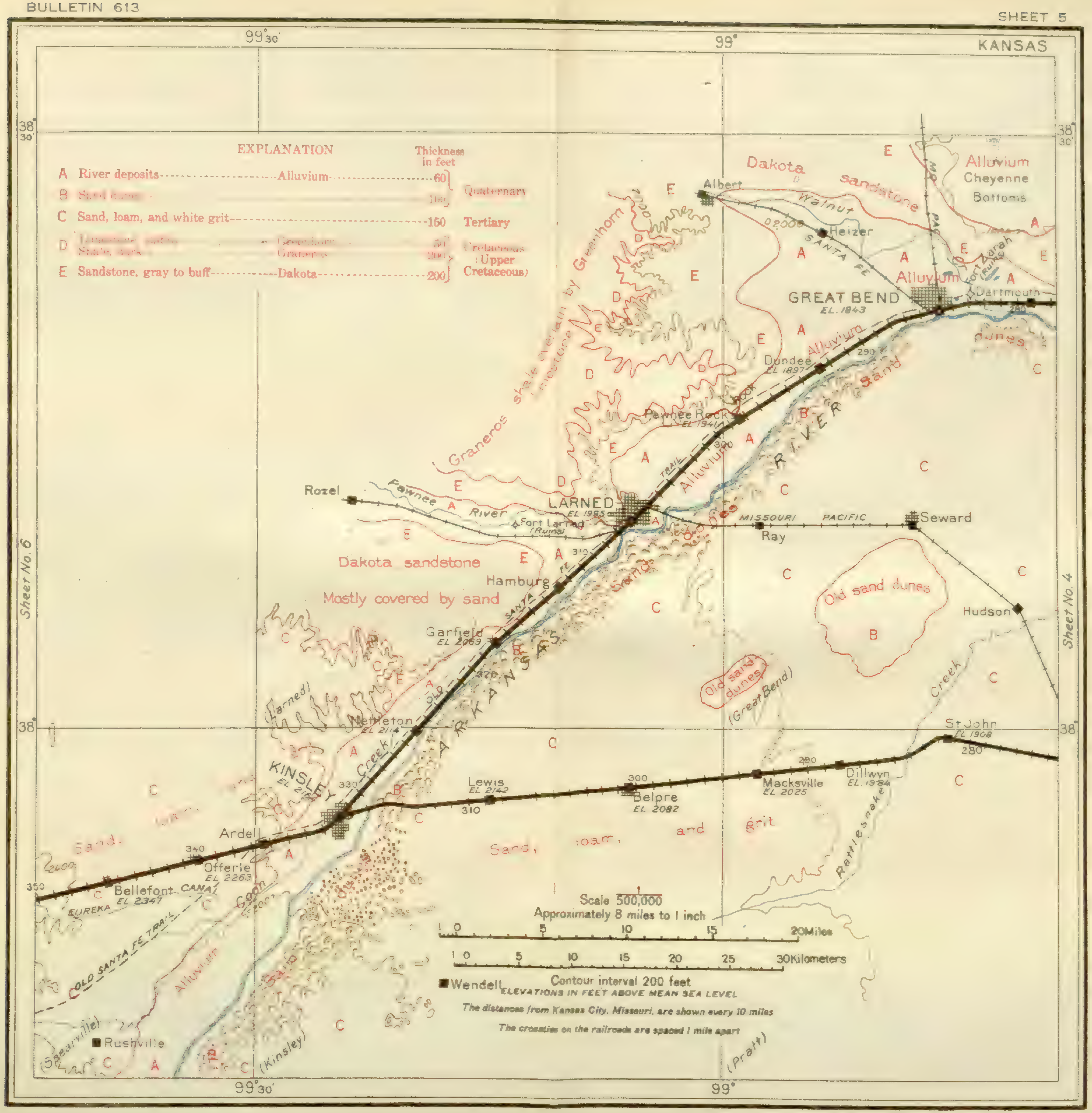

Just across the river from Dodge was, until 1835, the northeast corner of Mexico, and between 1835 and 1845 the corner of the Republic of Texas, the boundary of which extended from that point along the south side of Arkansas River to the Rocky Mountains. An account of the famous frontier characters formerly known around Dodge is out of place here, but they figure in many narratives and romances of earlier days, when it was widely known as the "wickedest town in the country." Now it is a model of peacefulness and tranquillity.

Change is made here from Central time to Mountain time, one hour earlier.

A short distance northwest of the station at Dodge are low cliffs of coarse sandstone and conglomerate of an older river channel of Tertiary age, lying on fine buff loam which extends down to the valley level. The formations underlying Dodge have been explored by a boring 1,100 feet deep which yielded nothing of value except some water from the Dakota sandstone that did not have pressure sufficient to flow.

From Dodge westward to La Junta, Colo., the Santa Fe Railway follows the Arkansas Valley, continuing along the north side of the river, in most places within a mile of it. A branch line crosses the river there and goes southwestward to Elkhart, near the Oklahoma State line. The Arkansas Valley in this vicinity is from 2 to 3 miles wide in greater part and is bordered by moderately steep slopes or bluffs on the north side of the river and by a wide zone of sand hills

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amounts in the shaggy coats of the buffaloes, who delight to wade or roll in a water hole. For years during the decline of the buffaloes, and after they had gone, their bones were a source of revenue for many persons, who collected them on the prairie and shipped them east to manufacturers of fertilizers. At some stations near Dodge the shipments averaged a carload a day in 1875. Gen. Sheridan estimated that originally the buffaloes between Fort Dodge and Camp Supply, in northwestern Oklahoma, aggregated 100,000,000 head, and in many of the great hunts some parties killed as many as 250 a day. After the Santa Fe Railway reached Dodge over 200,000 buffalo hides, 200 cars of hindquarters, and 2 cars of buffalo tongues were shipped the first winter. Buffaloes were so numerous, even after the railway had been built, that when they were crossing the track trains had to wait many hours until the herd had passed. Their slaughter by the whites was a cause of bitter dissatisfaction to the Indians and occasioned many conflicts. Their practical extermination was effected in about 20 years. Many were shot wantonly by passengers on the trains, and thousands were hunted for the sake of boasting of a great kill. Usually the white hunter took only the hide or a small part of the meat (hump or tongue), while the Indian utilized every part, including the intestines. The Indians despised the white man's methods, for the Indians killed by hunting on horseback with arrows or long spears, so that the number slain was small and probably never in excess of the natural increase. The Indians knew that when the buffaloes were gone their most important resource for food and clothing would cease to be available. The last buffalo in Kansas is said to have been sold at Kingman in 1888.

on the south side. For many miles the surface is made up of sand and loose sandstone or conglomerate of Tertiary age. The valley has been cut by the river to a depth of 250 feet below the adjoining great plateau, but it is partly filled with about 100 feet of sand and clay (alluvium) deposited by the stream, and these materials are still in course of deposition. In places the valley is cut through the Tertiary deposits into underlying shale and limestone of Upper Cretaceous age, but these do not appear at the surface until they rise in the valley slopes near Hartland. In ascending the valley the railway skirts slopes that rise 100 feet or more above the river flat to a plain of remarkable smoothness which ascends gradually westward at about the same rate as the upgrade of the valley. In these slopes are widely scattered outcrops of the Tertiary deposits—loam and sand with interbedded hard layers of coarse sandstone or conglomerate of gray color or of white "grit" consisting of sand and gravel cemented with calcium carbonate.

At a point halfway between mileposts 358 and 359, 6 miles west of Dodge, a small exposure of conglomerate is visible from the train. A granite marker at this place indicates the former course of the Santa Fe Trail, which extended up the north or American bank of the river very near the course of the present railway line from Dodge to Bents Fort, Colo.

Howell.

Elevation 2,537 feet.
Kansas City 377 miles.

Several small ledges of conglomerate appear for a short distance on the north side of the track at Howell and again just beyond milepost 363, a mile and a half west of Howell. At milepost 365 the sand hills on the south side of the valley are visible, and they extend almost continuously along that side of the river into Colorado.

In places high on the slopes to the north may be seen an irrigation canal intended to carry water from the river to the high plain north of Dodge and thence to Wright and Spearville. The intake of this canal is a short distance west of Ingalls, and by following a grade somewhat less than that of the fall of the river, the canal finally reaches the level of the plains at a point 3 miles northwest of Dodge. The Arkansas is a stream of large annual flow, but as much of its water is carried at times of freshet and as the volume at other times is exceedingly variable, there is often considerable difficulty in maintaining a regular supply in the canal during the growing season. In the future, no doubt, the freshet waters of this river, as well as of most other large streams in the United States, will not be allowed to escape but will be held in suitable storage reservoirs to maintain a flow.

It will be noted that west of Dodge the valley contains fewer trees than it does to the east and that still farther west in the region of more arid climate the trees along the valley diminish greatly in number. There are also fewer cultivated fields, although some alfalfa and wheat are grown. Pastures are much more extensive, for the raising of cattle increases in importance as the cultivation of the land becomes more difficult.

Cimarron.

Elevation 2,618 feet.
Population 587.
Kansas City 386 miles.

The village of Cimarron (sim-ar-rohn′) derived its name, which is Spanish for wild or unruly, from Cimarron Crossing, a ford some distance to the west, where the short cut or Cimarron branch of the Santa Fe Trail crossed Arkansas River. This branch passed through the sand hills, crossed the plains to Cimarron River, and went southwest to Wagon Mound and Fort Union. Cimarron was an important place in the time of the Santa Fe Trail. In the early days it was headquarters for many hunters, for buffaloes and other plains game were especially abundant in this vicinity. Later it was an important cattle center, but in recent years agriculture by dry farming and irrigation has become the principal industry, although there are still many cattle in the region. A large amount of wheat is raised, but the climate is too arid to assure good crops every year without the aid of irrigation.

At points 2 and 3 miles west of Cimarron the railway is on the river bank and passes through cuts showing buff loams of the deposits of Tertiary age that form the Great Plains.

Ingalls.

Elevation 2,665 feet.
Population 722.*
Kansas City 393 miles.

A mile west of Ingalls are railway cuts exposing hard layers of conglomerate, which also crop out in banks extending down to the river. This conglomerate consists of sand and gravel that have been cemented by calcium carbonate, which was in solution in waters percolating through the deposits. It marks the course of river channels that crossed the region in late Tertiary time and deposited the materials of the Great Plains. There are other exposures of this conglomerate at intervals farther west nearly to Garden City.

Pierceville.

Elevation 2,752 feet.
Population 477.*
Kansas City 405 miles.

A prominent ledge of this rock that crops out close to the railway 2 miles west of Pierceville is known as Point of Rocks. At this place there were several Indian fights. Toward Garden City (see sheet 7, p. 44) the Arkansas Valley widens, the bluff on the north side receding northward and becoming a gentle slope, which continues for several miles west.

Garden City.

Elevation 2,829 feet.
Population 3,171.
Kansas City 418 miles.

Garden City, the seat of Finney County, has wide streets, with many shade trees, orchards, and garden plots sustained by irrigation. It is the center of an extensive beet-sugar industry, and a large refinery is prominent in the northern part of the town. In 1914 about 50,000 tons of beets were worked at the refinery, yielding 13,000,000 pounds of sugar. The pulp is used for cattle feed. Several canals bring water from Arkansas River, not only for irrigation in the town but for many fields and orchards in the surrounding region. Two electric-power plants furnish power for pumping at a low rate.

At several places in the valley individuals and the beet-sugar company have been pumping water from shallow wells for irrigating crops and in general the results are satisfactory. Some of the wells yield 2,000 gallons a minute, and the supply appears adequate.

Near Garden City an irrigation project of the United States Reclamation Service, utilizing the underflow, or water contained in the sands and gravels of the low lands along the river, has been carried out. The plant is installed at Deerfield, 15 miles west of Garden City, where a number of shallow wells sunk in line across the valley are pumped to supply water for a ditch that extends along the north slope of the valley to Garden City and beyond. The cost of pumping is low because the surface of the water is not far beneath the bottom of the valley and the volume is large. Of late, however, the persons for whom the water was provided have found that it costs more than they desire to pay, so that the operation of the plant has been suspended.

The people in the Arkansas Valley in western Kansas have been asserting for many years that since the river water has been used so extensively for irrigation in Colorado the underflow in Kansas has greatly diminished. This matter was in a degree involved in the famous suit in the Supreme Court for an injunction against the State of Colorado in 1901–1907. Many experts testified for the defense that the main body of underflow was derived from the slopes adjoining the valley and that its volume was not closely related to the amount of water flowing down the river, except possibly for a few rods from the banks. Detailed observations at the wells at Deerfield and other test wells sunk by the Government proved that the line of flow in the valley deposits was mainly from the sides toward the middle.[1] The

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[1] A detailed investigation on the underflow in the Arkansas River valley in Kansas was made in 1904 by the United States Geological Survey. It was found that near Garden City the water table of this valley slopes downstream, and from the bluff lands in toward the river during ordinary stages. If, however, the river became flooded by heavy rains to the west without corresponding rains in the vicinity of Garden City the water table near the channel was raised and water spread from the river channel into the sands of the river valley, but only for a short distance. It was further ascertained that a heavy rain at Garden City would materially raise the water table in the valley with surprising quickness. The general results were as follows:

"The underflow of Arkansas River moves at an average rate of 8 feet per 24 hours in the general direction of the valley.

"The water plane slopes to the east at the rate of 7.5 feet per mile and toward the river at the rate of 2 to 3 feet per mile.

"The moving ground water extends several miles north from the river valley. No north or south limit was found.

"The rate of movement is very uniform.

"The underflow has its origin in the rainfall on the sand hills south of the

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
SANTA FE ROUTE
From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

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1915

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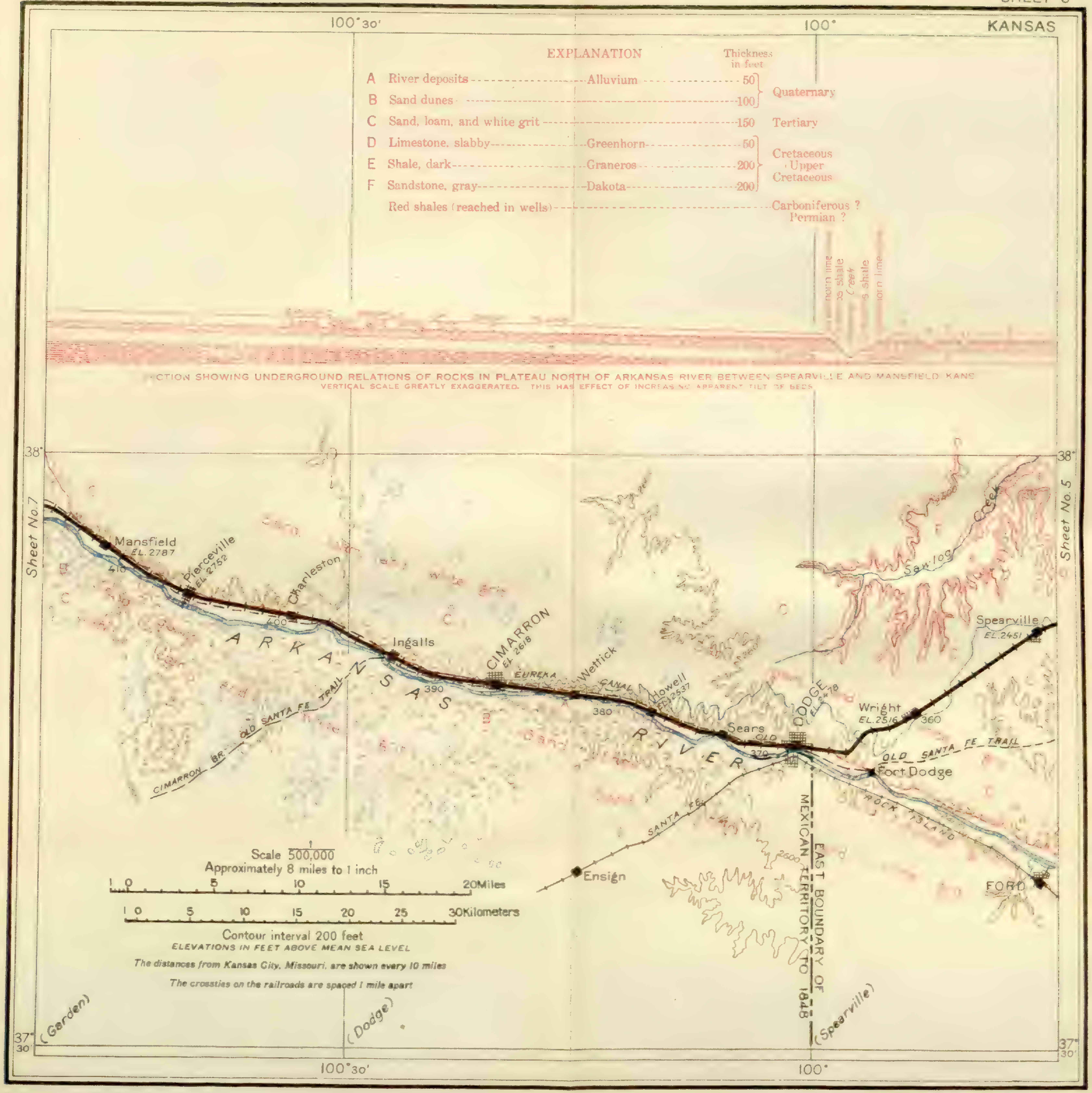
KANSAS
100°30'
100°
EXPLANATION
Thickness in feet
A River deposits — Alluvium — 50
B Sand dunes — 100
Quaternary
C Sand, loam, and white grit — 150
Tertiary
D Limestone, slabby — Greenhorn — 50
E Shale, dark — Graneros — 200
F Sandstone, gray — Dakota — 200
Cretaceous Upper Cretaceous
Red shales (reached in wells) — Carboniferous ? Permian ?
horn lime
os shale
Creek
s shale
horn lime
SECTION SHOWING UNDERGROUND RELATIONS OF ROCKS IN PLATEAU NORTH OF ARKANSAS RIVER BETWEEN SPEARVILLE AND MANSFIELD KANS
VERTICAL SCALE GREATLY EXAGGERATED. THIS HAS EFFECT OF INCREASING APPARENT TILT OF BEDS
38°
Sheet No. 7
Sheet No. 5
Mansfield EL. 2787
Pierceville EL. 2752
Charleston
Ingalls
CIMARRON EL. 2618
EUREKA CANAL
Wettick
Howell EL. 2537
Sears
DODGE
Wright EL. 2516
Spearville EL. 2451
Fort Dodge
FORD
Ensign
ARKANSAS RIVER
OLD SANTA FE TRAIL
CIMARRON BR.
SANTA FE
ROCK ISLAND
Sawlog Creek
410
400
390
380
370
360
MEXICAN TERRITORY TO 1848
EAST BOUNDARY OF
Scale 1/500,000
Approximately 8 miles to 1 inch
1 0 5 10 15 20 Miles
1 0 5 10 15 20 25 30 Kilometers
Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart
(Garden)
(Dodge)
(Spearville)
37° 30'
100°30'
100°

thickness of the sands and gravels in this region ranges from a few feet to 400 feet, the thickness found in a boring in Garden City.

West of Garden City the traveler is fairly within the semiarid zone of the western United States, where there are large areas of public lands still available for settlement. On the plains and in the valleys the soil is rich, but in many places there is a lack of the water necessary for irrigation.

The settlers in the western counties of Kansas have had many vicissitudes, mainly caused by their constant struggle against the semiarid climate. After the terrible drought of 1860 thousands of settlers left the State. Those following the pioneers who failed in western Kansas have attacked their problems of home making with no more earnestness but with much greater success, owing to their better knowledge of the climate, of the available arid-land crops, and of methods of tillage. The dry and somewhat uncertain climate has been the greatest obstacle to permanent settlement on millions of acres of unirrigated land not only in western Kansas but in adjoining similar regions in Texas, Oklahoma, Nebraska, and South Dakota. The grain sorghums, such as Kafir, millo, and feterita, thrive under conditions of aridity and drought where corn is either a partial or a total failure. In 1893 the acreage planted to grain sorghums in Kansas was reported as well under 100,000 acres; in 1914 it was over 1,700,000 acres, and the average return per acre was several dollars higher than that for corn. In all these States the grain sorghums are now rapidly supplanting corn. Stock, however, is the principal resource of this region, for the country is generally covered with good grass which not only keeps cattle alive but fattens them for market. It is said that under ordinary conditions each head of stock requires from 5 to 10 acres of grazing land and usually more or less feeding during the severe portions of the winter.

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river and on the bottom lands and plains north of the river.

"The sand hills constitute an essential part of the catchment area.

"The influence of the floods in the river upon the ground-water level does not extend one-half mile north or south of the channel.

"A heavy rain contributes more water to the underflow than a flood.

"On the sandy bottom lands 60 per cent of an ordinary rain reaches the water plane as a permanent contribution.

"The amount of dissolved solids in the underflow grows less with the depth and with the distance from the river channel.

"There is no appreciable run-off in the vicinity of Garden City, Kans. Practically all of the drainage is underground through the thick deposits of gravels.

"Carefully constructed wells in Arkansas Valley are capable of yielding very large amounts of water. Each square foot of percolating surface of the well strainers can be relied upon to yield more than 0.25 gallon of water per minute under 1-foot head.

"There is no indication of a decrease in the underflow at Garden City in the last five years. The city well showed the same specific capacity in 1904 that it had in 1899."

Holcomb.
Elevation 2,877 feet.
Kansas City 424 miles.

At Holcomb, 7 miles west of Garden City, may be noted on the north side of the track a loader of the sort in general use for dumping beets from wagons into the freight cars. The ordinary crop of beets suitably irrigated is from 10 to 15 tons to the acre and they bring about $5.50 a ton at the place of delivery. The tops are also sold for stock feed at about $3 a ton. The cost of cultivation, harvesting, and handling is $30 to $40 an acre. One ton of beets yields about 250 pounds of refined sugar.

In the vicinity of Garden City and farther west the sand hills are very conspicuous south of the Arkansas, where they cover a district from 15 to 18 miles wide. This sand has been blown out of the river bed by the prevailing northwest winds. The sand is in a thick sheet, but is blown into dunes and dunelike ridges separated by irregular winding basins. Some of the dunes are 50 to 60 feet high, and many of them have crater-like holes blown out of their tops. Much of the sand-hill area contains bunch grass and kindred plants, but other portions are bare and the sand continues to be blown farther from the river with every strong wind, while new supplies are added from the river bed. This process can readily be seen on a windy day.

Deerfield.
Elevation 2,935 feet.
Population 152.
Kansas City 432 miles.

West of Holcomb the part of the valley north of the river narrows somewhat, but the slopes are gentle and are mostly covered with crops, so that there are no exposures of the underlying formations. In this vicinity and at Deerfield the north side of the valley presents a broad second terrace or step, 50 to 100 feet higher than the river flats, a feature not common along this river. A few rods east of Deerfield station and just south of the tracks is the pumping station of the United States Reclamation Service, where water has been pumped from a series of shallow wells as already described. For a mile west of Deerfield the railway is close to the river, and the banks show thick beds of loam and sand of the later river deposits. Northwest of Deerfield is Lake McKinney, a large reservoir supplied mainly by ditches from the river above Lakin. Its water is used for irrigation in a wide district south and northeast of Deerfield.

Lakin.
Elevation 2,991 feet.
Population 337.
Kansas City 440 miles.

Near Lakin the higher lands of the plains approach the river from the north, and in the next 2 miles the steep slopes rising to them are near the track. These sandy slopes present widely scattered outcrops of a white grit rock of Tertiary age. One conspicuous outcrop of this rock is north of the track, 5½ miles west of Lakin, where a knoll is capped by it. In this region there are occasional shallow railroad cuts in the alluvial materials of the valley fill.

Beyond Hartland the valley is narrowed greatly by the encroachments of high lands on the north and of the wide belt of sand hills on the south. The plain to the north is nearly 200 feet above the valley and is a smooth expanse characteristic of the Great Plains in general. Southwest of Hartland the Government set aside a part of the sand hills as a national forest for the cultivation of trees, but this area will be open to agricultural settlement after November, 1915. Just west of Hartland is the well-known Chouteaus Island, at a ford across the Arkansas. Here, in 1817, a French trader named Chouteau took refuge from the Indians, finally escaping. It was in this vicinity that Maj. Riley encamped in 1829 with the battalion that formed the first caravan escort sent out by the United States. On the other side of the river the battalion was met by a Mexican escort dispatched by the Mexican Government. In 1828 a party of travelers cached $10,000 in silver at this place, being too exhausted to carry it farther. A year later they went back and recovered it.

Hartland.
Elevation 3,049 feet.
Population 373.*
Kansas City 447 miles.

A short distance west of Hartland shales and limestone of Cretaceous age rise above the valley bottom and continue in sight on the north side of the track far westward into Colorado. The surface on which the deposits of the Great Plains were laid down was in places somewhat irregular. In this vicinity there was a hill of Cretaceous material to the west and a deep hollow in the region on the east, as has been disclosed by the excavation of the Arkansas Valley by later erosion through the Tertiary gravels into Cretaceous deposits. Two miles west of Hartland a slight arching up of the beds brings into view the Dakota sandstone, which crops out in a short line of low cliffs on the south bank of the river at the edge of the sand hills. North of the track in this vicinity, near milepost 437, a short distance east of Sutton siding, the railway is on the steep bank of the river and passes through deep cuts affording excellent exposures of the top beds of the Graneros shale, capped by the Greenhorn limestone at a plane about 20 feet above the tracks. These rocks are of Upper Cretaceous age. The shale is dark gray and mostly in thin layers. About 20 feet below its top are two hard layers consisting largely of shells of a small oyster (*Ostrea congesta*, a species which also occurs in large numbers in the Niobrara group). The overlying Greenhorn limestone, named from Greenhorn Creek, in Colorado, where it is extensively exposed, is soft and earthy and weathers to a light-yellow tint. It crops out at intervals to Kendall and beyond, but near Mayline and for a short distance farther west is hidden by wash on the slopes and the gravel and sand of a narrow terrace which borders the valley in that vicinity. This gravel has been dug extensively for ballast for the railway in pits a short

Kendall.
Elevation 3,123 feet.
Population 361.*
Kansas City 458 miles.

distance north of the tracks. The Greenhorn limestone is excavated for building stone in several quarries of considerable size a mile northwest of Syracuse, all visible from the railway.

Fort Aubrey, near Kendall, was one of the old forts garrisoned with troops to protect travelers on the Santa Fe Trail.

Syracuse.

Elevation 3,220 feet.
Population 1,126.
Kansas City 469 miles.

Syracuse is one of the larger villages of western Kansas and was long the center of extensive cattle interests before the range was broken up by homesteaders. It was settled in 1872 by a colony from Syracuse, N. Y. The Santa Fe Trail passes through the village, where a granite marker can be seen at the railway station. Syracuse has a picturesque hotel, named after the famous Cherokee half-breed Sequoyah. This Indian after being crippled in an accident turned his attention to sedentary pursuits. His great achievement was the invention of an alphabet founded upon the syllables of the Cherokee language. This was eagerly adopted by the chiefs of that tribe, and in a few months thousands of the Indians could read and write it. Sequoyah took part also in the organization of the reunited Cherokees into their new Cherokee Nation in Indian Territory, now Oklahoma.

At Syracuse the north side of the Arkansas Valley has slopes of soft impure limestone and shale, mostly covered with grass but in places exhibiting low cliffs of white Greenhorn limestone. Although soft and not very thick-bedded, it is useful for building stone, and it has been burned into lime to some extent. A part of this limestone consists of minute shells, called Foraminifera, because their shell coverings are full of pores or small holes. These tiny animals existed in large numbers in the sea from which the material in this limestone was deposited. Shells of extinct sea-living mollusks, somewhat similar to our oysters and clams, are also included in it, which indicates that this area was under the water of a sea or arm of the ocean in later Cretaceous time. This inundation covered a large portion of western America, for these limestones and shales occupy many thousands of square miles in western Kansas, eastern Colorado, New Mexico, and other States on the north and south, and it continued for a long time.[1]

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[1] Under the Greenhorn limestone is about 200 feet of dark shale (the Graneros) which is penetrated by many borings in the Arkansas Valley. This shale was clay or mud deposited in the sea in the earlier stage of the submergence above referred to, but the material of the Greenhorn limestone, very largely calcium carbonate, was separated from the water by animal and chemical processes at a time when the water was relatively clear or had ceased depositing clay. This water remained clear during the long time required for the accumulation of a deposit now represented by 50 to 60 feet of limestone.

DEPARTMENT OF THE INTERIOR

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
SANTA FE ROUTE
From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

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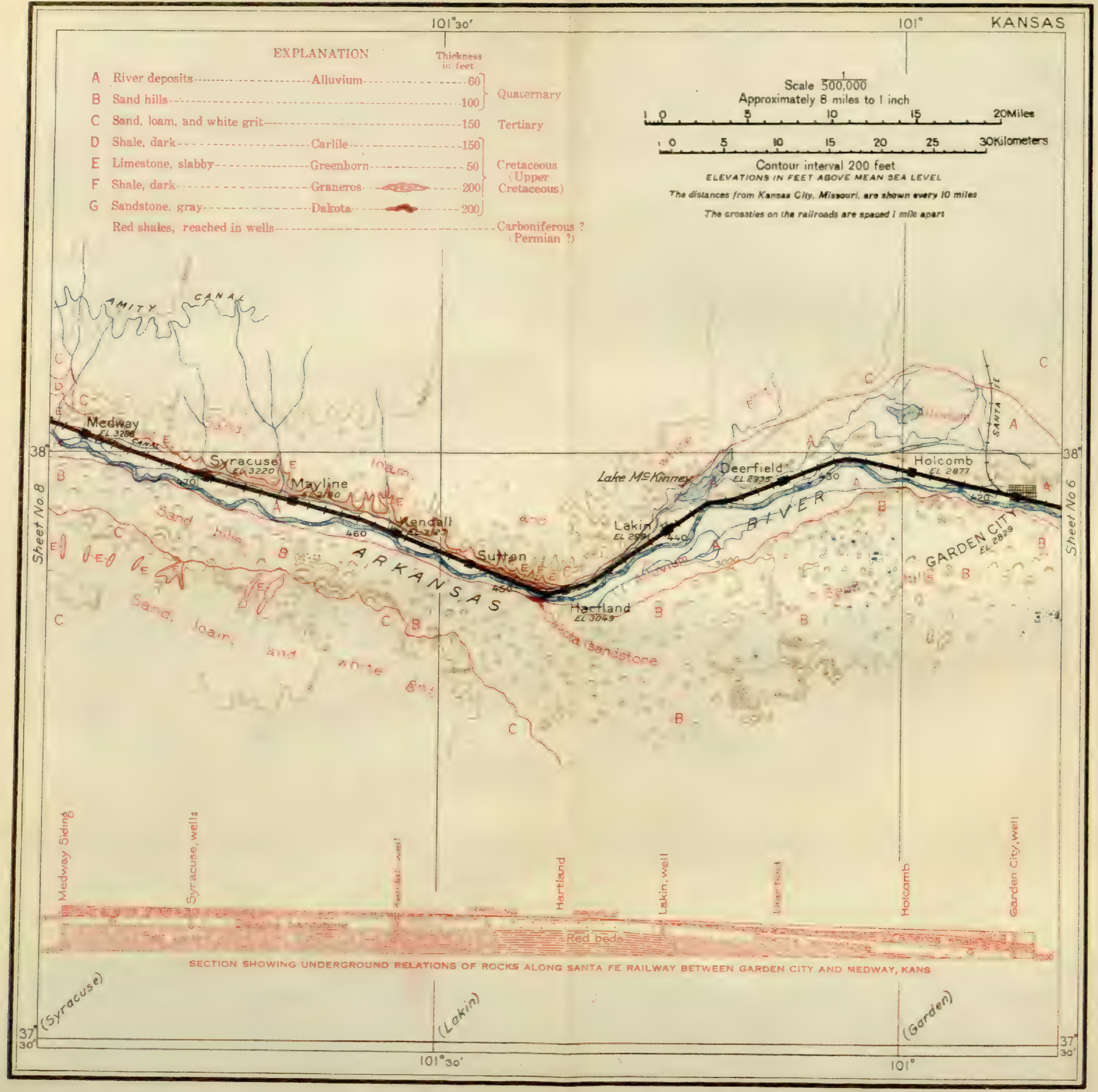
KANSAS
101°30'
101°
EXPLANATION
Thickness in feet
A River deposits — Alluvium — 60
B Sand hills — 100
Quaternary
C Sand, loam, and white grit — 150
Tertiary
D Shale, dark — Carlile — 150
E Limestone, slabby — Greenhorn — 50
F Shale, dark — Graneros — 200
G Sandstone, gray — Dakota — 200
Cretaceous (Upper Cretaceous)
Red shales, reached in wells — Carboniferous ? (Permian ?)
Scale 1/500,000
Approximately 8 miles to 1 inch
0 5 10 15 20 Miles
0 5 10 15 20 25 30 Kilometers
Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart
AMITY CANAL
Medway
EL 3288
Syracuse
EL 3220
Mayline
Kendall
EL 3123
Sutton
Hartland
EL 3049
Lakin
Lake McKinney
Deerfield
EL 2935
Holcomb
EL 2877
GARDEN CITY
EL 2829
SANTA FE
ARKANSAS RIVER
Sand hills
Sand, loam, and white grit
Dakota sandstone
470
460
450
440
430
420
38°
37° 30'
Sheet No 8
Sheet No 6
Medway Siding
Syracuse, wells
Kendall, well
Hartland
Lakin, well
Holcomb
Garden City, well
Red beds
Graneros shale
SECTION SHOWING UNDERGROUND RELATIONS OF ROCKS ALONG SANTA FE RAILWAY BETWEEN GARDEN CITY AND MEDWAY, KANS
(Syracuse)
(Lakin)
(Garden)

A quarry in the Greenhorn limestone is visible from the railway a short distance west of Syracuse, and low bluffs of the rock appear at intervals to and beyond Medway siding. The table-land above the slope on the north side of the valley is capped by the great sheet of Tertiary deposits already mentioned. The low white cliffs appearing at many points near the top of this slope consist of the characteristic grit of these deposits. On the south side of the valley is the broad zone of sand hills which continues to and beyond Coolidge.

Coolidge, Kans.

Elevation 3,341 feet.
Population 145.
Kansas City 484 miles.

East of Coolidge (see sheet 8, p. 48) and for a short distance west of it there are scattered ledges of Greenhorn limestone along the foot of the slope on the north side of the valley, but most of the slopes are gentle and grass-covered, as the rocks are too soft to form prominent bluffs.

Coolidge was named for T. J. Coolidge, a former president of the Santa Fe Railway Co. It is near the eastern limit of the Arkansas Valley artesian area, in which flowing wells are obtained along the bottom lands nearly as far west as the foot of the Rocky Mountains. The artesian condition ends on the east because finally, through leakage of water to the surface, the head becomes too low to afford a flow.

The State line between Kansas and Colorado is crossed six-tenths of a mile beyond milepost 470.

Colorado.

Colorado has an area of 103,948 square miles and contains varied physical features and many natural resources. Its eastern part lies on the higher portion of the Great Plains, and its western part includes a broad area in the higher portion of the Rocky Mountains. Numerous rivers afford water for irrigation, by which large crops are produced in many districts; the mountains have productive mines of gold, silver, and other metals; thick beds of coal occur in several regions; and wide areas are utilized for stock raising. More than 200 of the mountain peaks in central Colorado are higher than 13,000 feet above the sea, and 40 are over 14,000 feet. The highest are Elbert and Massive mountains, in Lake County, each of which rises 14,402 feet.

When the early Spanish explorers passed through Colorado they found no people, but ruins of many habitations. Lieut. Pike discovered the Rocky Mountains in 1806 and Col. Long visited them in 1820. Frémont crossed this range in the northern part of the State in 1843. Part of the area was included in the Louisiana Purchase, part was included in the Republic of Texas, and the remainder was ceded by Mexico in 1848. Settlement began in 1858, when the discovery of gold at Platte River, near the site of Denver, drew a large tide of immigrants. The Territory of Colorado, which was organized in 1861, included portions of Kansas, Nebraska, New Mexico, and Utah. The Civil War and depredations by Indians greatly retarded its development, but in 1876 the State was admitted to the Union. In 1910 the population was 799,024 and the density 7.7 to the mile, or nearly twice as great as in the census of 1890.

Holly, Colo.
Elevation 3,379 feet.
Population 724.
Kansas City 490 miles.

Holly is a center for ranch and cattle interests. Three-quarters of a mile to the west, on the north side of the track, is a large beet-sugar factory, utilizing the sugar beets which are raised by irrigation in adjacent portions of the valley. The Santa Fe Trail passed through this place and its location is marked by a granite monument opposite the station. A short distance to the south is an old stone building built in 1873 for protection against Indians. In the vicinity of Holly, and thence to Amity, the valley slopes present few rock outcrops excepting occasional ledges of nearly horizontal beds of Greenhorn limestone.

Amity.
Elevation 3,410 feet.
Kansas City 495 miles.

The village of Amity was created by the industrial division of the Salvation Army for the purpose of giving outdoor work to a colony of 250 persons connected with that organization. It was started as "Fort Amity" in 1898, with a tract of 1,800 acres. Considerable land has been cultivated, mainly for the production of sugar beets to send to the factory at Holly. The broad alluvial flats along the north side of the river are especially suited to the cultivation of this plant, which is irrigated by water brought in canals from higher up the valley. This industry is increasing, and now there are six factories between Pueblo, Colo., and Garden City, Kans., that have a total capacity of about 5,000 tons of beets a day.

Just beyond milepost 480 the railway crosses Arkansas River, to continue on the south bank to La Junta. A branch, however, intended for local service in the valley, especially in connection with the sugar-beet industry, leaves the main line at Holly and follows the north slope of the valley as far as Rocky Ford, famous for its cantaloupes. In the Colorado portion of the Arkansas Valley, which the railway follows to La Junta, about 205,000 acres is irrigated from the river, and there are many ditches for distributing and several large reservoirs for storing water.[1] Fruit, grain, vegetables (including 27,350 acres of sugar beets), and forage crops are the principal products.

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[1] The mean discharge of the Arkansas at La Junta, determined by gagings by the United States Geological Survey, is 338 second-feet—that is, cubic feet a second. In dry times the flow diminishes to less than 10 second-feet, and at times of flood it has exceeded 10,000 second-feet.

Granada.

Elevation 3,438 feet.
Population 359.
Kansas City 501 miles.

Granada is built near the site of the great cattle depot of Trail City in the days of the Santa Fe Trail. Here one of the principal trails from Texas reached the river and large numbers of southern cattle were delivered to herders, who drove them to the northern ranches. In this vicinity the river is in a wide valley, with level floor and long slopes rising on each side to the table-lands of the Great Plains. The railway is on the alluvial deposits, only a few feet higher than the river. In the adjoining slopes are outcrops of various rocks of the Cretaceous period. The relations of these rocks are shown in the section on sheet 8 (p. 48). The beds form a basin-like sag in the vicinity of Granada, so that the Greenhorn limestone lies several hundred feet deep, and the overlying shales and limestones constitute the surface. These shales (the Carlile), about 200 feet thick, together with the overlying limestone (the Timpas), crop out in low bluffs a short distance south of Granada, as well as in the slopes on the north side of the valley. The limestone is quarried to some extent for building stone and lime. It is soft and chalky and is very similar to the Greenhorn limestone in most respects, but occurs in somewhat thicker beds.[1] A 1,000-foot well at Granada obtains water from the Dakota sandstone, underlying the Graneros shale, but the pressure is not great enough to afford a flow, as in the many borings farther up and down the valley.

Grote.

Elevation 3,486 feet.
Kansas City 507 miles.

West of Granada the rocks rise gradually. In the vicinity of Grote siding the Greenhorn limestone comes up again, although near the river it is covered by the alluvial deposits which floor the valley. Near milepost 496 the Dakota sandstone reaches the surface, and except for a short distance at Lamar it appears all along the lower portion of the valley slopes to Las Animas and beyond. The structural relations of the strata which result in the cropping out of the Dakota sandstone are shown in the section on sheet 8.

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[1] The Timpas limestone contains impressions of shells and large numbers of Foraminifera, showing that it was deposited by the sea under conditions very similar to those which prevailed during the time of the deposition of the Greenhorn limestone.

There is in this succession of limestone and shale formations an interesting chapter in geologic history, the Graneros and Carlile shales consisting of deposits from muddy water and the Greenhorn and Timpas limestones consisting of deposits from waters containing but little clay or sand in suspension. These conditions were widespread over a great extent of the plains country east of the Rocky Mountains, for this repeated alternation of shale and limestone is general throughout the area. During this time there was a great variety of life in the waters, as shown not only by large numbers of shells but remains of fish and reptiles, especially in the Niobrara beds. A restoration of one of the most remarkable creatures is shown in Plate V, *B*. This restoration was based on bones found in the Niobrara rocks in western Kansas.

Between mileposts 495 and 496 there is a long railway cut 5 to 10 feet deep, through loam with interspersed beds of bowlders, gravel, and sand of the alluvial deposits that floor the valley and constitute a terrace slightly higher than the river flat to the east and west. The material was deposited by the river a few thousand years ago, and the variations in coarseness and texture were caused by alternations of swifter and slower currents, the former bringing coarse materials and the latter depositing silt and sand. Changes of channel are frequent in Arkansas River, as in many other large streams. A notable illustration of such a change is visible halfway between mileposts 496 and 497, where a new channel has been cut by a recent flood.

Lamar.

Elevation 3,577 feet.
Population 2,977.
Kansas City 518 miles.

Lamar, the seat of Prowers County, was named for L. Q. C. Lamar, a former Secretary of the Interior. It has extensive agricultural and cattle interests in the surrounding country. Besides several mills and factories, the town has a large milk-condensing plant, supplied by many dairy farmers in the vicinity. In 1914 the milk of 2,000 cows was being condensed. There is also a beet-sugar factory here, but of late it has not been in operation because the farmers in this vicinity have come to the conclusion that beet raising is not sufficiently profitable for them. Bees are kept in large numbers, and honey is an important local product.

Very few rocks are visible in the vicinity of Lamar, although ledges of the Dakota sandstone appear in some of the slopes southeast of the town and at many places farther west along the valley. This rock becomes conspicuous in the river bluffs at Prowers and west of that place on both sides of the stream. It is exposed along or near the railway from milepost 509, 1½ miles east of Prowers, nearly to Las Animas. Near milepost 520 the railway cuts expose shale, which separates some of the beds of Dakota sandstone at most localities. The predominant features of the formation, however, are the cliffs of massive coarse gray sandstone. This material is used to some extent as a building stone, although much of it is too slabby or irregular in texture or color to be of any great value for that purpose.

Caddoa.

Elevation 3,758 feet.
Population 329.*
Kansas City 537 miles.

Caddoa derives its name from the linguistic family of which the Pawnee and Wichita Indians of this vicinity were branches. Here the immediate river valley is narrow, bluffs of Dakota sandstone rising from the alluvial flat near the stream on both sides. To the north these bluffs are surmounted by an irregular terrace covered with gravel and sand, and to the south they are interrupted by sandy slopes partly occupied by dunes. A well at Caddoa, bored 582 feet deep, passed through the Dakota sandstone but did not obtain a very satisfactory water supply in its lower portion, and the water did not have sufficient pressure to come to the surface.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
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From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

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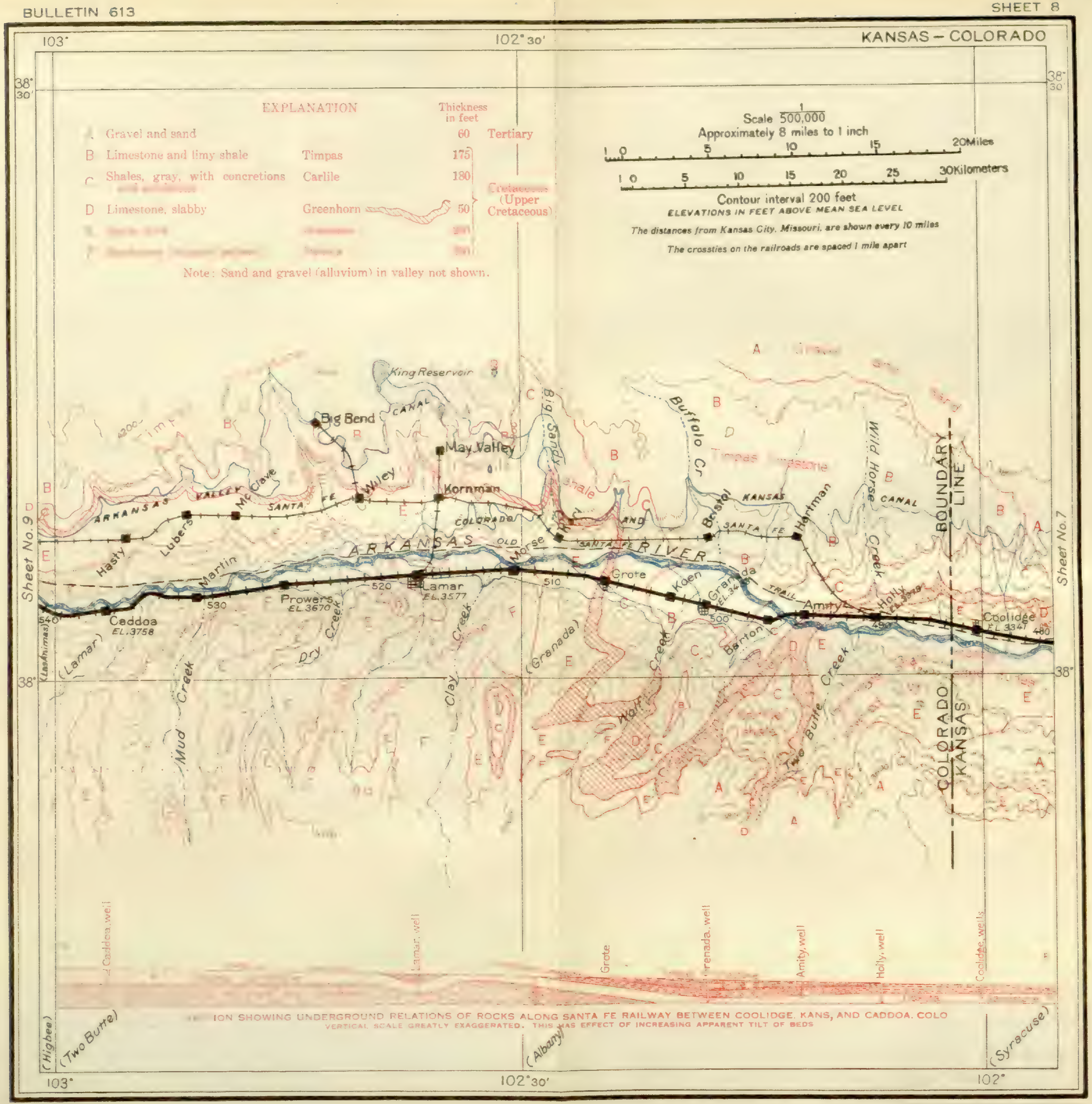

Opposite Hilton siding (see sheet 9, p. 54), about three-quarters of a mile beyond milepost 526, is old Fort Lyon, a well-known military post on the Santa Fe Trail, which was an important depot of supplies. A regiment of soldiers was garrisoned there to give protection to travelers. The old fort is on the top of the bluff of Dakota sandstone on the north side of the river, and the few remaining buildings are plainly visible from the railway. They are now utilized as a United States naval sanitarium. Seven miles northeast of this fort a boring was sunk 815 feet by the United States Government in 1881 to test the underground-water conditions. It cost more than $18,000 and obtained only a very small flow of water, but it gave considerable information as to the succession of strata.

At milepost 534 the railway crosses Purgatoire River, which flows from the south and drains a large area of the western Great Plains in southeastern Colorado; the railway reaches it again at Trinidad. This river was named Río de las Ánimas Perdidas (river of lost souls) by the Spaniards because of the loss of a party of travelers in its treacherous waters. The French visitors translated this to Purgatoire, which the frontiersmen pronounce and spell "Picketwire," and that name is now in local use.

Las Animas.

Elevation 3,856 feet.
Population 2,008.
Kansas City 551 miles.

Las Animas (ahn′ee-mas), the seat of Bent County, derives its name from the Spanish name for Purgatoire River. It is said that from this locality in 1806 Lieut. Zebulon Pike first saw the peak which now bears his name.[1] One of the principal industries of Las Animas is a large beet-sugar factory, the beets for which are raised at many places in the vicinity by means of irrigation from ditches extending along the north side of the valley. Besides beets, of which the yield is 25 tons to the acre, much wheat is produced here, and all along the valley from Las Animas to Rocky Ford the famous Rocky Ford cantaloupes are raised.

On the outskirts of Las Animas, not far west of the station, on the south side of the track, is a small settlement of Mexicans living in characteristic adobe houses. This is the first of these settlements to be observed on the Santa Fe route, but they are very numerous through southwestern Colorado and New Mexico. The old home of the noted scout Kit Carson, at Las Animas, is still in existence, and another survivor of the old days is the stage coach in which Horace Greeley toured the West in 1859.

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[1] Pike's expedition ascended Osage River and crossed the country northwestward to the Pawnee Republic, in Republic County, Kans., where he compelled the Indians to haul down the Spanish flag. He then proceeded southwestward to Great Bend, Kans., and ascended the Arkansas to the foot of the mountains in Colorado.

A few miles west of Las Animas, on the north bank of the river, was Bents Fort,[1] a noted place on the Santa Fe Trail. This fort was very prominent in the days when the Army of the West marched through in 1846, but it was demolished in 1852 because the Government would not purchase it at the price asked. The building was a very large (180 by 135 feet) one-story structure 15 feet high, with walls 4 feet thick, situated several miles above the junction of Purgatoire and Arkansas rivers, where the trail crossed Arkansas River. In early days the Arkansas was the northern boundary of Mexico westward from a point near Fort Dodge. On crossing the river the caravans passed from the protection of United States troops to that of Mexican soldiers.

Five miles west of Las Animas the railway approaches bluffs of dark Graneros shale capped by the Greenhorn limestone, which extend along the south bank of the river for some distance to the west. A slight westerly dip finally carries the shale below the surface of the alluvial filling of the valley, but cliffs or ledges of the limestone are almost continuous nearly to La Junta. These ledges consist of alternating thin beds of limestone and dark shale, a feature which is highly characteristic of this formation and is shown in Plate VI (p. 52). In an exposure 20 feet high there may be thirty alternations of such beds. This feature indicates that, at the time of their deposition, there were rapid and repeated changes from muddy water, depositing dark clay, to clear water, from which the calcium carbonate, now represented by the limestone, was separated. It is thought that these changes were due to changes in climatic conditions. As this feature is characteristic of the Greenhorn limestone in a region more than 2,000 miles from north to south and 500 miles from east to west in the Great Plains province, it shows that the conditions of deposition were uniform over a wide area.

On the north side of the river flat west of Las Animas is the edge of a table-land showing bluffs at intervals, in which are many small outcrops of the Timpas limestone, a formation about 200 feet higher in the geologic column than the Greenhorn. Outlying areas of this table-land some distance south of the tracks may be seen at intervals for 6 miles. A few rods east of milepost 552 a small canyon south of the railway shows the characteristic alternation of shale and limestone beds in the Greenhorn limestone.

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[1] The Bent family was prominent in frontier history and established successive trading posts, each known as Bents Fort, among the Indians. The original post, up the river toward Pueblo, Colo., was built in 1828. The fur-trading firm of Bent & St. Vrain was next in size to the American Fur Co. Charles Bent was appointed Territorial governor of New Mexico by Gen. Kearney when the Army of the West took possession of Santa Fe. William Bent, one of the brothers, was a "squaw man," having married the daughter of a Cheyenne chief. His son, after receiving a good education in St. Louis, gathered about him a band of savage Indians and became so dangerous an outlaw that the Government offered $5,000 for his capture.

La Junta.
Elevation 4,046 feet.
Population 4,154.
Kansas City 570 miles.

La Junta (hoon'ta), the seat of Otero County, is a railway division point where all trains stop for change of engine and meals are served. Here also the line for Colorado Springs and Denver branches off, continuing westward up the valley of Arkansas River to Pueblo. La Junta is a very old town for this part of the country. Seventy years ago it was an important trading center on the Santa Fe Trail which crossed the river a short distance below and from La Junta continued southwest near the line of the present railway to Trinidad. A stone monument a block south of the station marks its location in La Junta. The principal industrial interests here are the large railway shops, but the city also has the trade of an extensive adjacent ranch country. The name is a Spanish term, meaning junction, and refers to the convergence of the old trails at this place. Much of the water supply of La Junta is obtained from artesian wells sunk through the limestone and shales to the porous Dakota sandstone, in which the water is under enough head to afford a flow.

The long westward journey across the plains terminates a short distance west of La Junta, and beyond may be seen the eastern edge of the Rocky Mountain ranges, rising above the western edge of the plains and extending from north to south, presenting a magnificent panorama. The sight of these mountains cheered the hearts of the overland wagon-train immigrants after their dreary marches across the plains, and it still cheers the sons of the West as they return to their mountain homes and also welcomes the stranger to the Cordilleran country. These ranges extend 270 miles southward, to Glorieta Pass, and in order to get around them the railway now begins to turn in the same direction and will soon enter a region that presents interesting phenomena along their foothill margin.

A short distance west of La Junta the route leaves the valley of Arkansas River. It crosses the plains toward the foothills of the Rockies, following a course nearly due southwest to Trinidad. It is close to the old Santa Fe Trail all the way. There is a continuous upgrade, at first on long, gentle slopes of the Timpas limestone,[1] a rock which appears in numerous cuts and small outcrops along the track to and beyond Timpas siding.

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[1] The Timpas limestone, which was so named from its occurrence on Timpas Creek, is widespread in the central Great Plains region and constitutes the lower formation of the Niobrara group. The principal body of limestone is from 50 to 60 feet thick in most places and grades upward through 100 feet or more of limy shales and thin-bedded limestone to the Apishapa shale, the upper formation of the Niobrara group. The gray shales of the Apishapa constitute the hills west of Timpas siding and they are also crossed by the railway farther southwest.

In this region the strata rise southwestward at a rate slightly greater than that of the railway grade. This structure is shown on the cross section on sheet 9, which represents not only the attitude of the rocks but also the relative thickness of the formations and facts revealed by deep borings at intervals.

Timpas.

Elevation 4,409 feet.
Kansas City 588 miles.

The old Santa Fe Trail passed 400 feet east of the site of the station at Timpas. A short distance beyond this place the Timpas limestone caps mesas [1] or buttes of considerable prominence, especially along the east side of the track, and a little farther southwest it extends southward in a long line of low westward-facing cliffs. Below these cliffs are slopes of Carlile shale, at the foot of which, near Ayer, is a bench of the Greenhorn limestone. Along this portion of the valley of Timpas Creek, on both sides, are excellent exposures of long, sloping mesas capped by the Timpas limestone. This rock, though soft as rocks go, is much harder than the shales and remains where the overlying shale is washed away. The limestone caps project in a cliff presenting the greater part of the thickness of the formation. Most of the mesas slope to the northeast because the limestone dips in that direction.

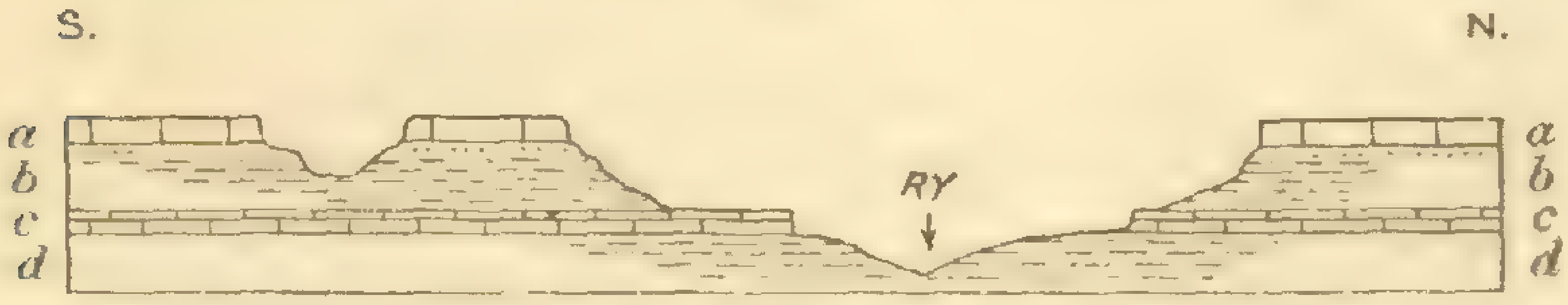

FIGURE 6.—Section across Timpas Creek valley near Bloom, Colo., looking southwest. *a*, Timpas limestone; *b*, Carlile shale; *c*, Greenhorn limestone; *d*, Graneros shale.

Bloom.

Elevation 4,773 feet.
Kansas City 601 miles.

From Symons to and beyond Bloom the ordinary features presented in the Timpas Creek valley are a low, wide bench or shelf of Greenhorn limestone at or near the bottom and a slope of about 200 feet of Carlile shale, rising to a cliff at the edge of the tabular surface of the mesa of Timpas limestone. (See Pl. V, *A*, p. 29, and fig. 6.)

The areas of Timpas and Greenhorn limestones carry a small growth of "cedars" (*Juniperus occidentalis*), termed sabina by the people of the country. The cane cactus (*Opuntia arborescens*) becomes conspicuous in this vicinity and is abundant to the south and west through Colorado and New Mexico, together with flat-leaved cactuses of various species. (See footnote on pp. 155–156.)

The Dakota sandstone is exposed a short distance west of the railway at milepost 590, being brought up by a low dome, as shown in the cross section on sheet 9. The outcrop of this sandstone extends to Delhi and beyond, with the adjoining higher slopes of shales and limestone in a relation closely similar to those shown in figure 7.

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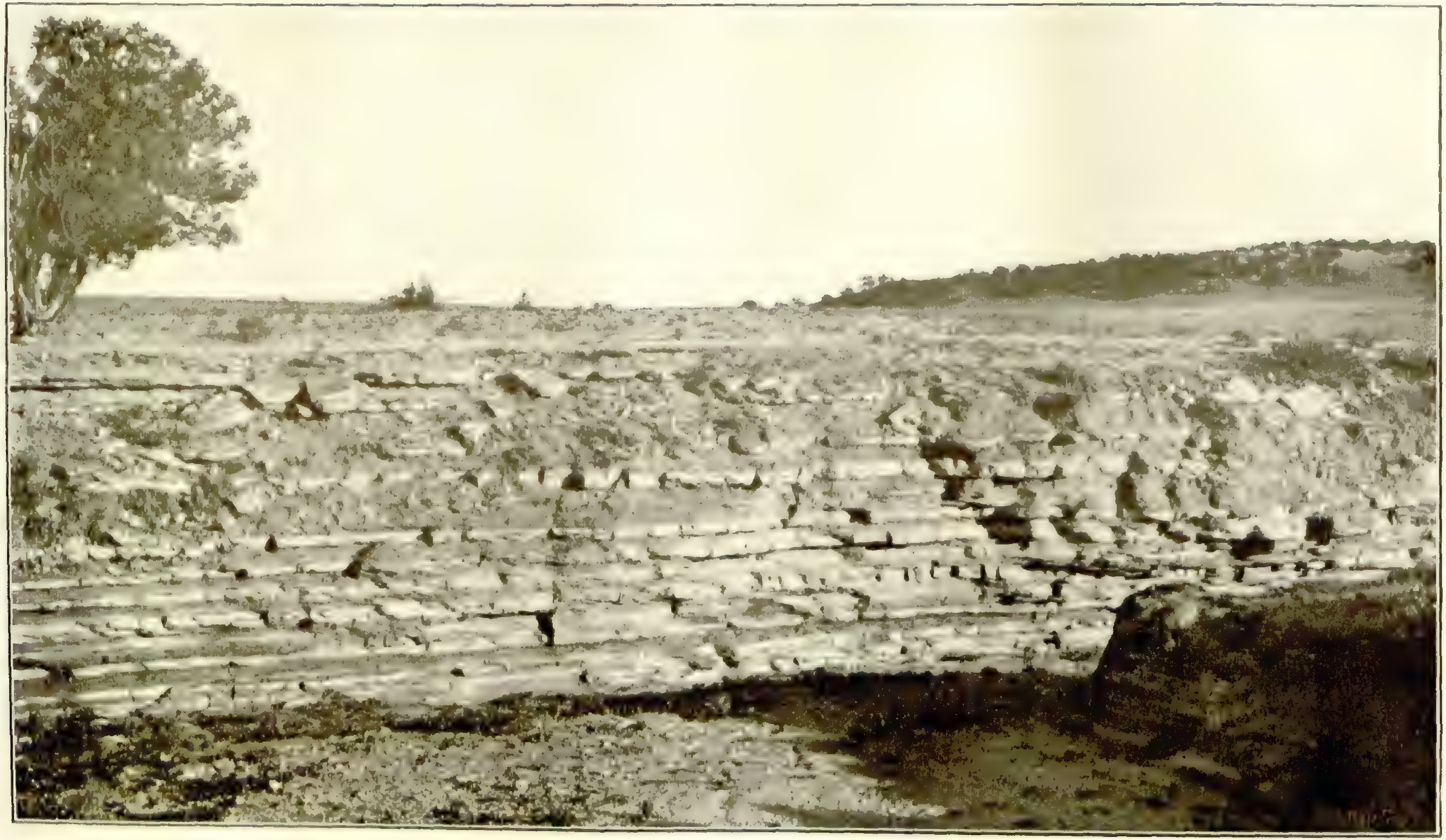
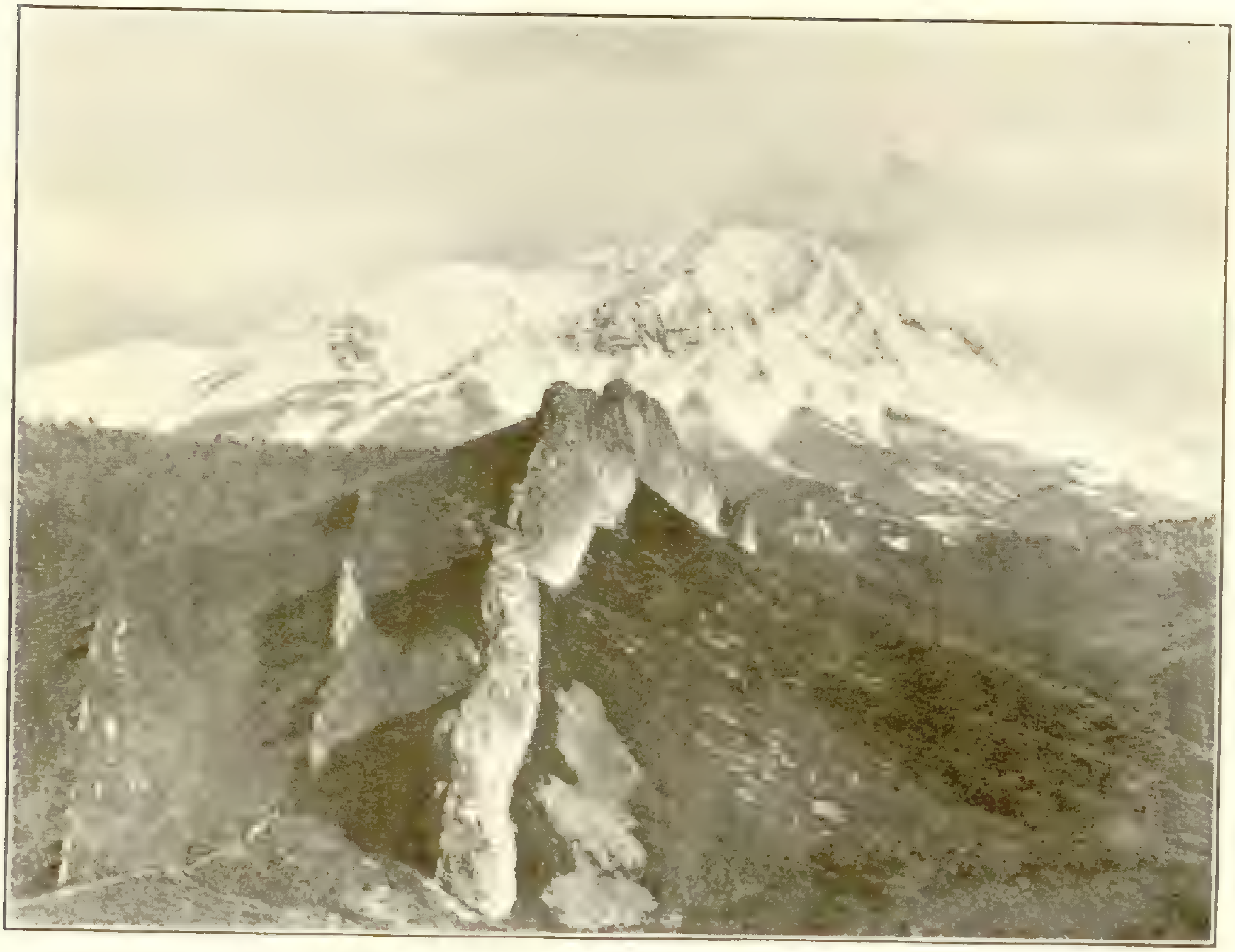
[1] Mesa (may′sa), a Spanish word meaning table, is applied to a flat-topped butte or hill, while one that has a sloping tabular surface is called a cuesta (kways′ta), from one of the Spanish words for hill.



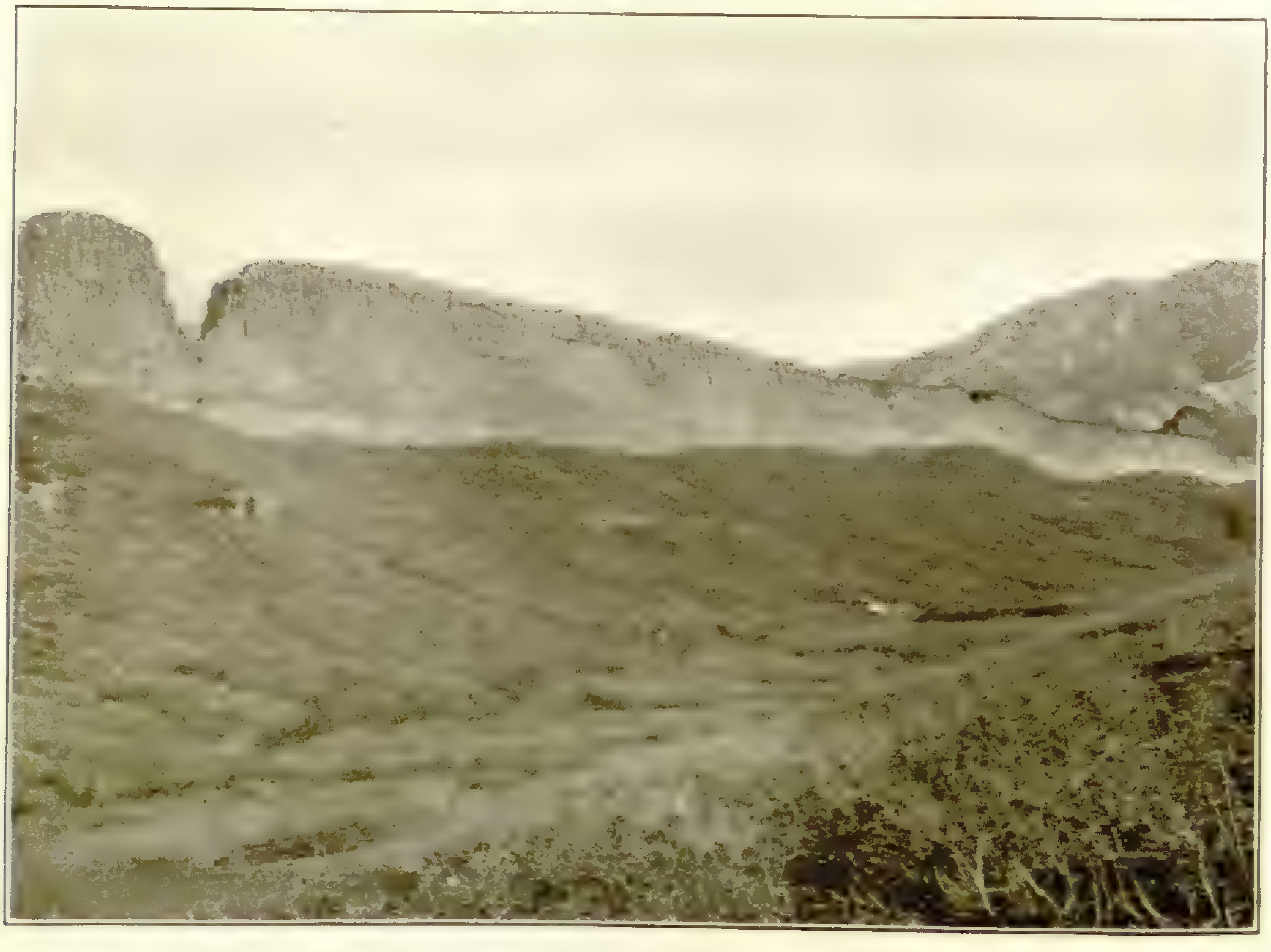
GREENHORN LIMESTONE NEAR THATCHER, COLO.

Shows characteristic alternation of thin layers of limestone and shale, indicating rhythmic changes in conditions of deposition.



A. WEST SPANISH PEAK, COLO., FROM THE NORTHEAST.

Dikes of igneous rock in foreground. Flat-lying Tertiary rocks in middle slope of the mountain.



B. DIKE OF IGNEOUS ROCK FORMING NARROW WALL, SPANISH PEAKS, COLO.

Delhi.

Elevation 5,042 feet.
Kansas City 607 miles.

At Delhi the railway crosses the Santa Fe Trail, the old wheel tracks of which are plainly visible in the slope rising to the west. A few rods west of Delhi a deep canyon cuts through the Dakota sandstone and exposes the beds of the shales and sandstones of the underlying Purgatoire formation (Lower Cretaceous). At West siding the Dakota sandstone again appears in the bottom of the valley west of the railway, and from a point a few miles south of West to and beyond Thatcher the railway runs along the top of this sandstone and the lower edge of the Graneros shale is a few rods to the east. This feature is due to a slight upward arching of the beds that are cut into by the valley. The relations of the formations in this vicinity are shown in figure 7.

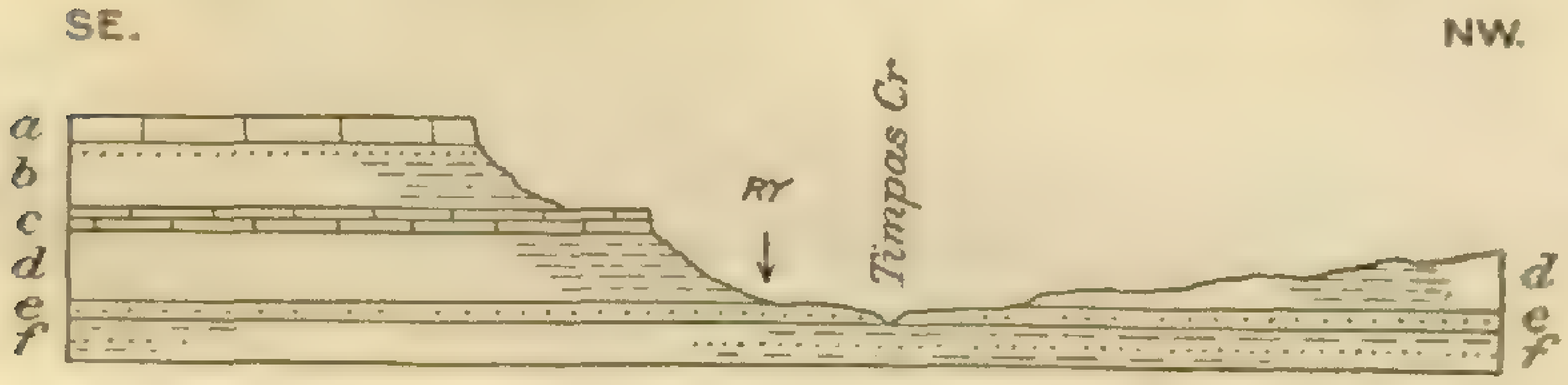


FIGURE 7.—Section across Timpas Creek valley at Thatcher, Colo., looking southwest. *a*, Timpas limestone; *b*, Carlile shale, with sandstone at top; *c*, Greenhorn limestone; *d*, Graneros shale; *e*, Dakota sandstone; *f*, Purgatoire formation.

Thatcher.

Elevation 5,400 feet.
Population 37.*
Kansas City 616 miles.

A short distance east of Thatcher is a bench of Greenhorn limestone with scattered junipers, and at the top of the mesa beyond is the Timpas limestone with numerous junipers. The old Santa Fe Trail extends southwestward along the west slope of the valley in this vicinity, its course being marked by a granite monument a mile west of Thatcher. A few miles farther southwest the railway again crosses the trail.

Southwest of Thatcher the railway passes from the Dakota sandstone across the Graneros shale, the bench of Greenhorn limestone, and the slope of Carlile shale, reaching the summit of the plateau of Timpas limestone a short distance beyond Simpson siding. (See sheet 10, p. 62.) The smooth surface of this plateau extends for 10 miles or more southwestward along the railway, rising gradually. From its summit are visible far to the west the Spanish Peaks (Pl. VII, *A*), two symmetrical cones rising in front of the main range of the Rocky Mountains, which are conspicuous in the background. During much of the year the higher summits of all these peaks and mountains show considerable snow.

The Spanish Peaks consist of large masses of igneous rocks which were intruded in molten condition into the sandstones and shales at the foot of the Rocky Mountains. (See fig. 8, p. 54.) The east peak is 12,708 feet high and the west peak 13,623 feet. They were called Wahatoya by the Indians and Los Dos Hermanos (the two brothers) by the Spanish. It is to be regretted that the distinctive

Indian name has not been retained, especially as there are other Spanish Peaks in the West. A remarkable feature of this intrusion is the large number of narrow dikes of the igneous rocks, mostly branching from the large masses through cracks in the sedimentary strata and extending out in every direction for many miles from the foot of the peaks. Owing to their hardness they stand above the surface as narrow walls in many places. One of these is shown in Plate VII, *B*. The sandstones and shales adjoining the larger igneous masses are baked and otherwise altered by the heat of the intrusion and are considerably upturned.

Tyrone.

Elevation 5,520 feet.
Kansas City 624 miles.

Half a mile north of Tyrone a granite marker just east of the track indicates the location of the old Santa Fe Trail. Behind the Spanish Peaks rise the main Rocky Mountains, here called Sangre de Cristo Range (sahn'gray day cris'to, Spanish for blood of Christ). Fishers Peak, east of Trinidad, is also visible from the plateau about Tyrone, but is almost straight ahead of the line of railway. Five miles beyond Tyrone the train enters a wide area of shale (Apishapa) lying nearly level and extending to Hoehne siding. The shale includes limy layers, some of them of light color and many of them weathering to a light-yellow tint. One of the best exposures is in a ditch north of the track, near milepost 620, where the unweathered shale is black. The water of this ditch is brought from Purgatoire River, some distance to the southwest, and serves to irrigate a small area about the new village of Poso, which is at milepost 615.

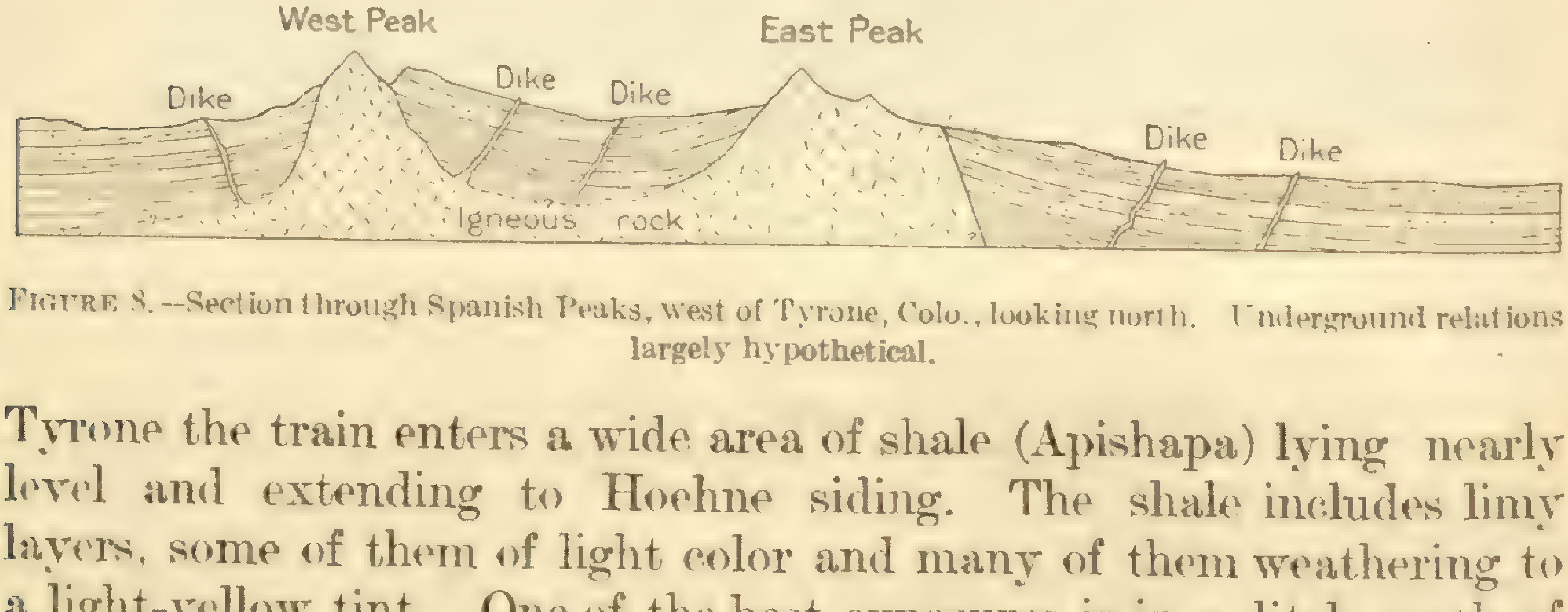
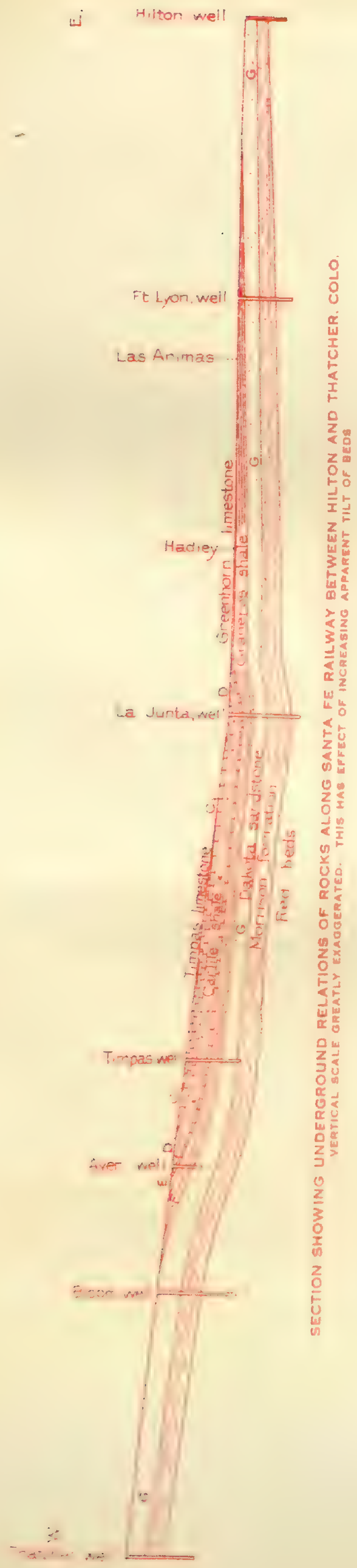


FIGURE 8.—Section through Spanish Peaks, west of Tyrone, Colo., looking north. Underground relations largely hypothetical.

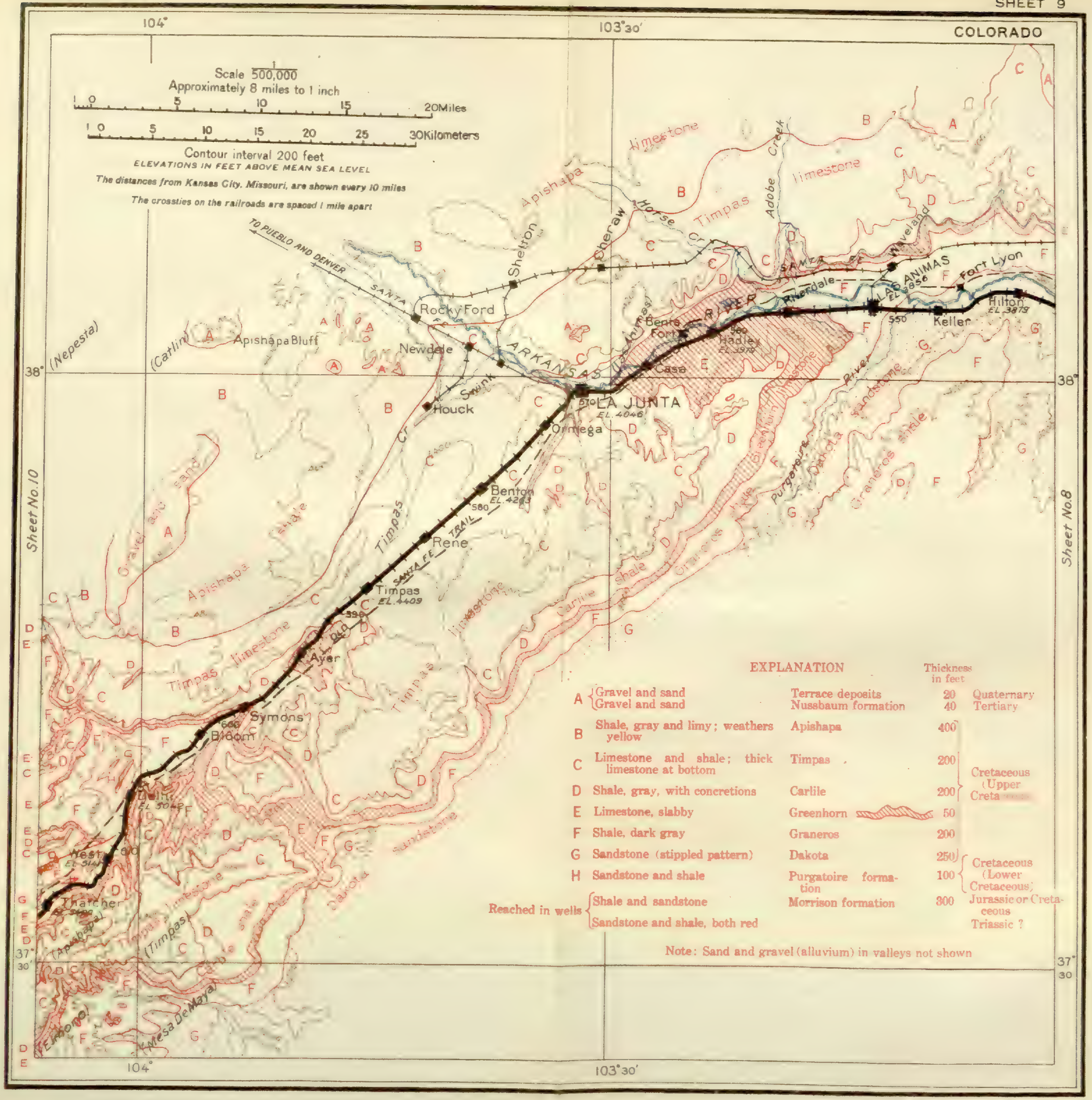
Earl.

Elevation 5,673 feet.
Kansas City 634 miles.

Beyond Earl the route crosses a low ridge of Apishapa shale and thence southwestward descends into the valley of Purgatoire River, the west side of which is followed to Trinidad. This stream, which was passed farther east at Las Animas, brings considerable water from the mountains west of Trinidad and is especially subject to freshets, some of which cause great damage along the lower part of the valley. The greatest known flood, in 1904, had a volume of 45,000 second-feet. In 1912 nearly 36,000 acres of land was irrigated by water from this stream, most of it in the region between Trinidad and Las Animas.



SECTION SHOWING UNDERGROUND RELATIONS OF ROCKS ALONG SANTA FE RAILWAY BETWEEN HILTON AND THATCHER, COLO.
VERTICAL SCALE GREATLY EXAGGERATED. THIS HAS EFFECT OF INCREASING APPARENT TILT OF BEDS


COLORADO
104°
103°30′
38°
37° 30
Sheet No.10
Sheet No.8
Scale 1/500,000
Approximately 8 miles to 1 inch
0 5 10 15 20 Miles
0 5 10 15 20 25 30 Kilometers
Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart
TO PUEBLO AND DENVER
SANTA FE
ARKANSAS RIVER
Rocky Ford
Newdale
Swink
Houck
LA JUNTA EL. 4046
Ortega
Benton EL. 4263
Rene
Timpas EL. 4409
Ayer
Symons
Bloom
Delhi EL. 5042
Earl
Thatcher
Bents Fort
Casa
Hadley EL. 3976
Riverdale
LAS ANIMAS EL. 3856
Fort Lyon
Keller
Hilton EL. 3879
Cheraw
Shelton
Apishapa Bluff
Horse Cr
Adobe Creek
Timpas Cr
SANTA FE TRAIL
Purgatoire River
Apishapa
Timpas limestone
Carlile shale
Greenhorn limestone
Graneros shale
Dakota sandstone
Gravel and sand
Mesa De Maya
EXPLANATION
Thickness in feet
A {Gravel and sand | Terrace deposits | 20 | Quaternary
A {Gravel and sand | Nussbaum formation | 40 | Tertiary
B Shale, gray and limy; weathers yellow | Apishapa | 400
C Limestone and shale; thick limestone at bottom | Timpas | 200
D Shale, gray, with concretions | Carlile | 200
E Limestone, slabby | Greenhorn | 50
F Shale, dark gray | Graneros | 200
G Sandstone (stippled pattern) | Dakota | 250
Cretaceous (Upper Creta
H Sandstone and shale | Purgatoire formation | 100
Cretaceous (Lower Cretaceous)
Reached in wells {Shale and sandstone | Morrison formation | 300 | Jurassic or Cretaceous
Reached in wells {Sandstone and shale, both red | Triassic ?
Note: Sand and gravel (alluvium) in valleys not shown

At Hoehne a broad area of the Pierre shale [1] is entered. It extends to the base of the cliffs of Trinidad sandstone, 10 to 15 miles west and south of Hoehne. A short distance beyond milepost 627 is a narrow dike of igneous rock, probably an extension of one of those connected with the intrusion of the igneous mass in the Spanish Peaks. On account of the hardness of the rock, this dike makes a low but conspicuous ridge a short distance west of the railway.

Hoehne.

Elevation 5,706 feet.
Population 852.*
Kansas City 642 miles.

At Elmoro are extensive ovens in which the coal of the Trinidad field is made into coke,[2] for use in blast furnaces and smelters. Many Mexicans reside in the vicinity of Elmoro and Trinidad. Some of them belong to the order of "Penitentes," who from intense religious zeal suffer flagellation and other forms of bodily punishment, even to crucifixion. Many Mexicans in southern and central New Mexico belong to this order.

Elmoro.

Elevation 5,833 feet.
Population 579.*
Kansas City 647 miles.

Trinidad is a railway division point where all trains stop, some of them for meals at the Hotel Cardenas (car′day-nas), built in the mission style. The hotel is named in honor of García López de Cárdenas, who accompanied Coronado's expedition and was sent by him to find the great river of which the Indians spoke. This was the Colorado in the Grand Canyon, and Cárdenas was the first white man to see it.

Trinidad.

Elevation 5,967 feet.
Population 10,204.
Kansas City 652 miles.

Trinidad owes much of its importance to the coal mining in the surrounding hills. It is also a railway center, and there are many ranches in the adjoining region which bring considerable trade. It is the terminus of a branch of the Denver & Rio Grande Railroad and is on the line of the Colorado & Southern Railroad from Denver to Texas.

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[1] The Pierre shale is about 1,200 feet thick. It consists of a remarkably uniform succession of thin layers of compact dark-gray to black clay, representing a large part of the later Cretaceous succession in a wide area of the central Great Plains. It was deposited while this broad area continued to be occupied by the sea, the limy sediments of the Apishapa being succeeded by the almost pure clay of which the Pierre shale consists. As the material was a sediment from muddy waters, it was undoubtedly deposited slowly, and therefore a long time was required for the accumulation of so thick a body of it. Its marine origin is indicated by numerous remains of shells of many kinds which lived only in sea water. The Pierre shale is not well exposed along the Santa Fe route, for, owing to its softness, it has been washed down into gentle slopes, mostly covered with sod.

[2] Coke is the product obtained by the distillation or partial combustion of certain grades of bituminous coal in retorts, or ovens, at high temperatures. When the process is one of partial combustion, as in ovens, it is accomplished by the admission of a limited supply of air into the combustion chamber, the oxygen thus supplied being sufficient for the combustion of the volatile matter in the coal only. In retorts the heat is applied through flues on the outside of the retort by the combustion of the gases distilled from the coal. By either process the coal is changed into the cellular, silvery product known as "coke." In the Trinidad region the former method is the only one employed.

At Trinidad the plains give place to the high, rugged foothills of the Rocky Mountains. This change is due to the fact that here the Pierre shale is overlain by the Trinidad sandstone, which is surmounted by 2,000 feet of shales and sandstones that are resistant to erosion. The shales and sandstones above the Trinidad sandstone contain valuable deposits of coal. These coal-bearing rocks extend along the foot of the mountains for many miles in southern Colorado and southward for some distance in New Mexico. They are nearly horizontal in the vicinity of Trinidad. The prominent mountain mass southeast of Trinidad consists of coal measures and overlying strata capped by a thick sheet of black lava (basalt), constituting an extensive plateau with nearly flat top, known as Raton Mesa. One spur of this mesa projecting northward for some distance is named Fishers Peak after a German artillery officer who commanded a battery in the Army of the West that camped at its foot in 1846.

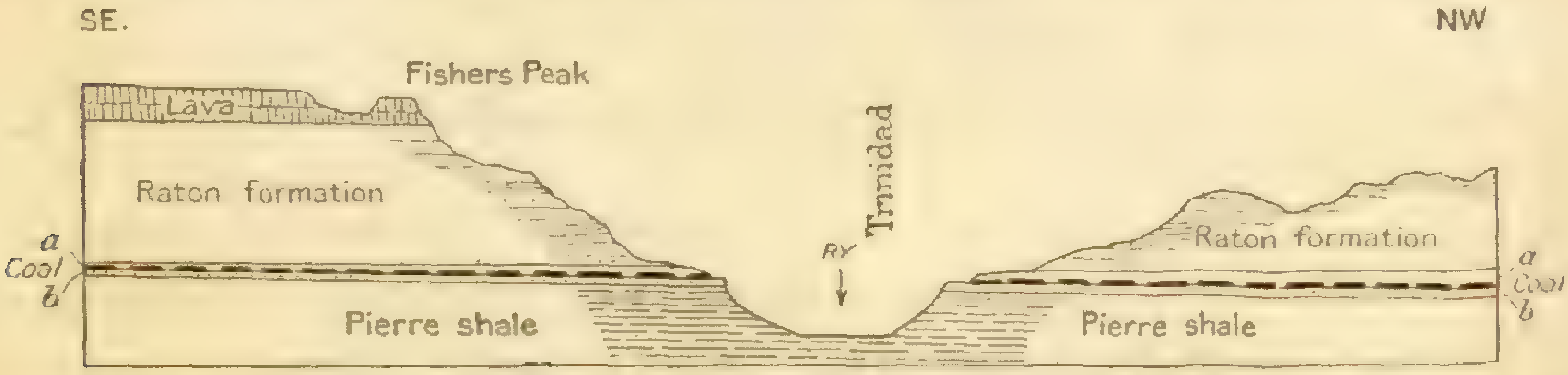
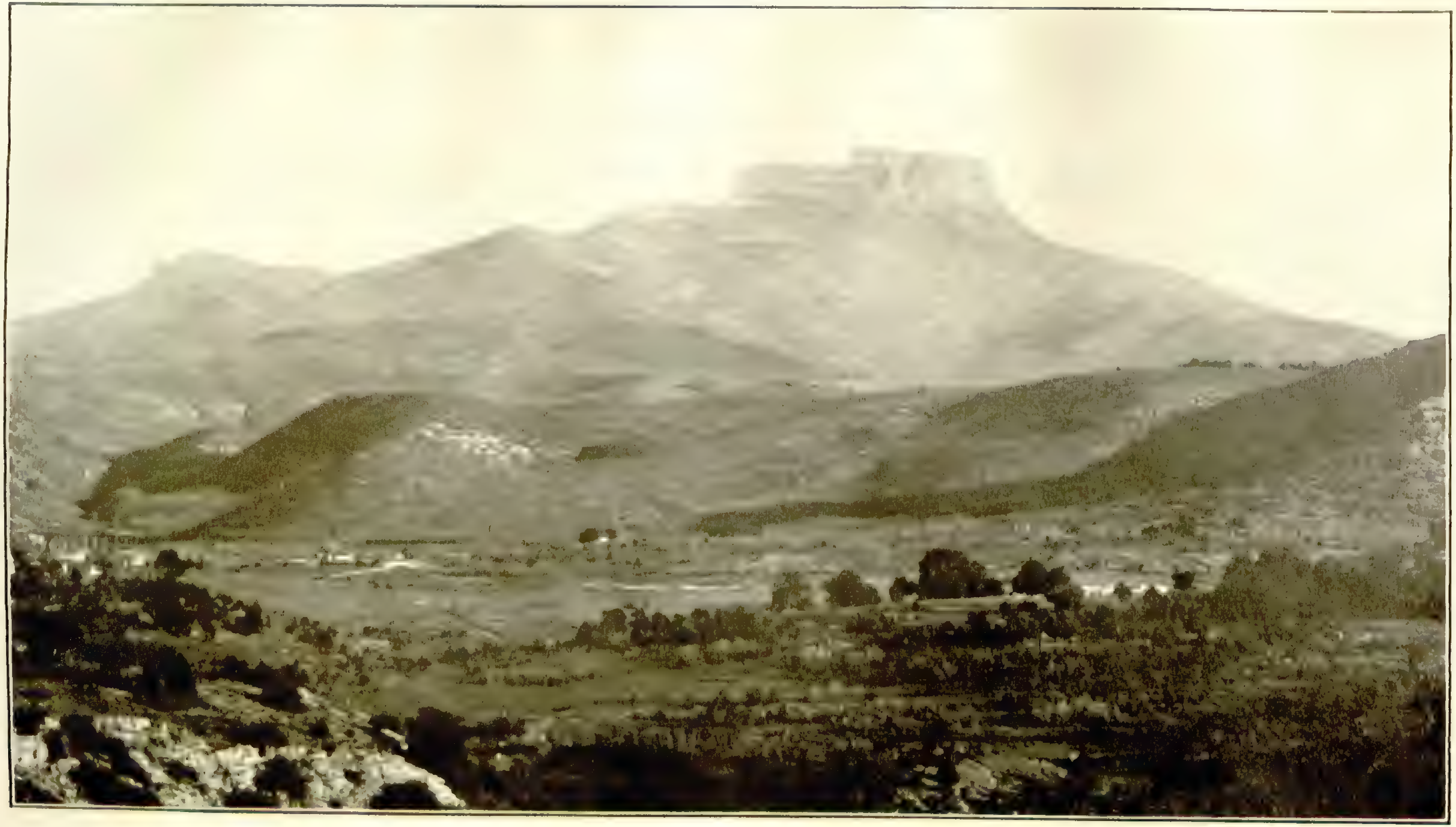


FIGURE 9.—Section through Trinidad, Colo., showing relations of rocks, looking southwest. *a*, Vermejo formation with coal bed; *b*, Trinidad sandstone.

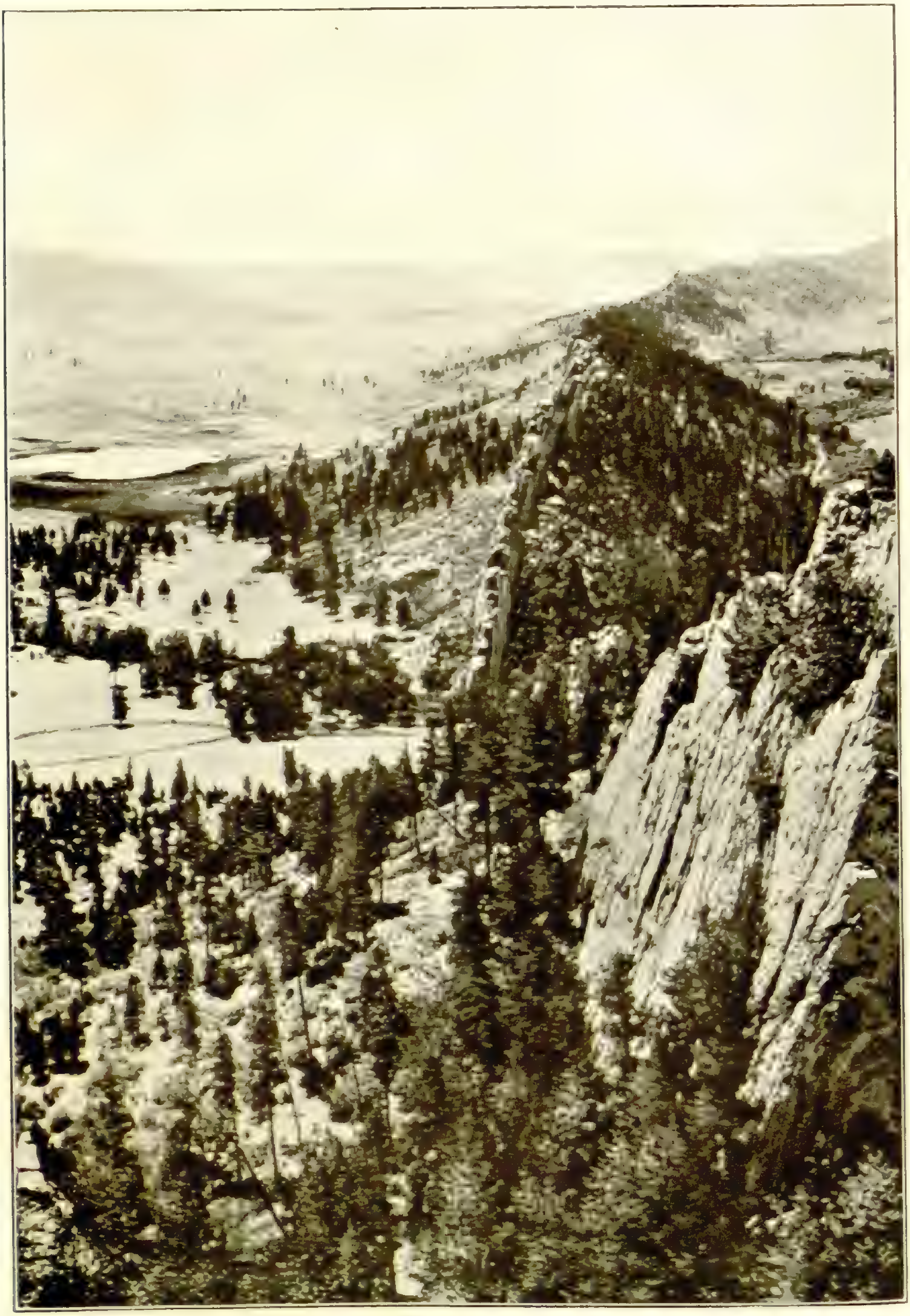
Its altitude is 9,586 feet, or more than 3,600 feet higher than Trinidad, so that it is a conspicuous object for many miles north and east. It is shown in Plate VIII. The mesa or plateau, which extends south from this peak, has a relatively level top about 20 square miles in area and is the remnant of a widespread lava flow that was poured out over the surface prior to the excavation of the valleys that are now so far below the mesa level. A portion of the same mesa, extending far to the southeastward at nearly the same altitude (8,511 feet), is known as Bartlett Mesa. A section from Trinidad southeastward to Fishers Peak and through Raton Mesa is given in figure 9. It is evident that many years have elapsed since the outflow of the lava sheet capping these mesas, because an enormous mass of material has been removed from the surrounding country, especially in the lower region to the north and east. However, the lava is geologically of relatively recent age, being considerably later than the middle of Tertiary time.

In the western part of Trinidad is a high ridge known as Simpsons Rest. Upon it stands an obelisk marking the grave of George Simpson, a noted mountaineer and trapper.



FISHERS PEAK, NEAR TRINIDAD, COLO.

View eastward. The peak and mesa, a projection of Raton Mesa, consist of a thick bed of lava which lies on nearly horizontal beds of coal measures of the Raton formation. Santa Fe Railway in shale valley in foreground.



WALL OF DAKOTA SANDSTONE WEST OF TRINIDAD, COLO.

Outcropping edge of sandstone upturned on east slope of Rocky Mountain uplift. Soft overlying shales to the left of the ridge and red beds to the right.

There are numerous coal mines in all the high hills adjoining Trinidad. The principal centers are at Gray Creek and Engleville, to the east; Starkville, Sopris, Cokedale, and Primero, to the southwest; and Berwin, Hastings, Delagua, and other camps, to the north. The coal field occupies a long, narrow basin of about 2,000 square miles along the foot of the Rocky Mountains. This region contains the largest and best deposits of bituminous coal west of Missouri River.[1]

The most extensive coal bed lies just above the Trinidad sandstone, which crops out prominently in the bluffs about Trinidad. This coal averages 6 feet in thickness but varies from place to place. In some localities there are several other beds within a short vertical distance. Most of the coal is of high rank and cokes satisfactorily. The coke is shipped to the smelters at Pueblo and to other places. Here and there in this coal field igneous rocks have been injected between the beds, and where coal is near by it has been altered to "natural coke." The yearly output from the general Trinidad region is given at about 6,000,000 tons of coal and 1,000,000 tons of coke. Numerous coal beds also occur at intervals in the rocks above the Trinidad sandstone, but they appear to be less widespread than the lower coal beds. The coal in this field was discovered in 1851 by the exploring expedition under Stephen H. Long, but it was not developed extensively until the Santa Fe Railway was built through and coal was required for use in the locomotives. This region was the scene of the long strike of coal miners in 1914, when serious conflicts occurred between the strikers and the State troops and strike breakers.

Jansen.
Elevation 6,058 feet.
Population 373.*
Kansas City 654 miles.

At Trinidad two extra locomotives, a helper and a pusher, are attached to the heavier trains to haul them up the steep grade to the Raton Pass, 10 miles south of Trinidad. The rise is 1,636 feet and the maximum grade 3½ per cent. The valley of the Purgatoire is followed for the first 2 miles to Jansen, where the line turns up the valley of North Raton Creek to begin the mountain climb. To the east, south, and west are cliffs or steep slopes (see Pl. IX) and a few miles to the southeast is Fishers Peak. In the valley occur scattered outcrops of the black upper shales of the Pierre formation, surmounted by cliffs of the massive gray Trinidad sandstone, about 100 feet thick, which underlies the coal measures. About 1¼ miles west of Jansen this sandstone crosses the valley, causing a cascade in the creek just east of the railway. A mile farther along the sandstone is quarried on the east side of the track.

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[1] The coal-bearing rocks occur in two formations. The lower one, known as the Vermejo formation, is generally from 200 to 400 feet thick, and the upper one, the Raton formation, is nearly 2,000 feet thick. Both formations contain large numbers of the remains of plants, those of the Vermejo being of Cretaceous age and those of the Raton of Tertiary age. There was an interval of time between the deposition of the Vermejo and that of the Raton, with slight uplift and considerable erosion, during which the lower coal was removed over a considerable area.

There are coal mines at intervals in the slopes, especially to the south, in the vicinity of Starkville, where there are several large mines and numerous coke ovens. The principal mine here is one of the largest and oldest in the field. The main opening is in a gulch east of the railway and the mine entries extend eastward under the slopes of Fishers Peak, emerging at Engleville, on the north side of the mountain, 3½ miles to the northeast. The coal has been removed from a large area beneath the mountain. The coke ovens on the east (left) side of the railway present a brilliant spectacle at night, for usually 30 or 40 of them are in operation. At a point a mile beyond Starkville there is a specially good view of Fishers Peak, the summit of which is about 3 miles east of the railway. Half a mile farther south the northern boundary of the Maxwell land grant, originally the Beaubien and Miranda grant,[1] is passed. This boundary line is marked by a sign east of the railway.

Starkville.
Elevation 6,333 feet.
Kansas City 657 miles.

As the train climbs the slope toward Raton Pass, the landscape changes greatly, for the high slopes present sandstone cliffs and clumps of pines grow along many of the ledges. Some of the cliffs are more than 100 feet high, notably in the vicinity of Gallinas siding.

At Morley a slight upward arching of the beds brings the top of the Trinidad sandstone and also the Pierre shale to view in the bottom of the valley, and the coal bed in the overlying Vermejo formation appears at the surface. There is one large mine just east of the railway. The coal bed crops out a short distance beyond, on the west side of the tracks, and also in the south portal of the tunnel just beyond Wootton siding. Other higher beds crop out at intervals in the next 2 miles.

Morley.
Elevation 6,748 feet.
Population 857.*
Kansas City 664 miles.

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[1] This grant was one of the many large concessions made by the Spanish Government to some of the early settlers in what are now New Mexico and southern Colorado. In the treaty with Mexico it was provided that the United States should recognize these grants, but as the boundaries were loosely defined and in some grants were misrepresented by claimants, there have been many contests over them. The question of the validity of this grant was in the courts for many years, but title was finally established. It includes about 1,750,000 acres, lying mostly in New Mexico, and it extends for 62 miles along the Santa Fe Railway. The grant came to Maxwell through his wife, the daughter of Beaubien, one of the original holders. Maxwell was a famous figure in the annals of the Southwest. For a while he was a trapper, but later as a scout with Frémont and others he was the hero of daring episodes. He will perhaps be remembered longest as the host of "Maxwell's ranch," at Cimarron, where he lived in considerable luxury and entertained many of the passers-by on the Santa Fe Trail.

The rocks a few hundred feet north of Wootton have yielded large numbers of fossil plants including remains of magnolias and palms. These indicate that when the formation was laid down the land surfaces which existed from time to time were covered by a semitropical vegetation very different from the pines, junipers, oaks, and other northern species which grow on the hillsides of this region to-day.

Wootton, Colo.

Elevation 7,495 feet.
Kansas City 667 miles.

At Wootton was the home of "Uncle Dick" Wootton, one of the famous scouts of the early days when emigrants were passing through the country and Indians were a source of great danger. The Raton Mountains were also a favorite hold-up place for highwaymen. Wootton was an associate of Kit Carson, and guided some of the military exploring parties. The portion of the wagon road passing over the Raton Pass was constructed by Wootton under charter from the legislatures of Colorado and New Mexico, and for many years he collected toll from those who traveled over it. Originally there was only a mountain trail through the pass, and considerable labor and expense were required to fit it for the passage of heavy wagons. In the ascent on the north side of the pass it crossed Raton Creek 53 times. In 1846, when Gen. Kearney and the Army of the West crossed these mountains on the way to take Santa Fe, it was necessary to draw the wagons up and let them down by ropes. The soldiers at this time were on half and third rations. The remains of Wootton's substantial adobe house, built somewhat like a southern plantation home, are visible on the wagon road west of the track.

A short distance beyond Wootton the train crosses the State line between Colorado and New Mexico. It was the intention that this line should follow the thirty-seventh parallel of latitude, but late surveys have shown that the line located on the ground was somewhat south of that parallel.

New Mexico.

New Mexico is one of our newest States, having been admitted to the Union January 6, 1912. It is less developed along industrial lines than its neighbors to the east and north. The main line of the Santa Fe Railway runs through it for 430 miles. The area of the State is 122,634 square miles, or slightly more than that of Colorado. It includes the south end of the Rocky Mountains and many outlying ranges of that system, together with wide plateau areas, in large part higher than 5,000 feet above sea level. Part of it was included in the Republic of Texas and part in Mexico. It was organized as a separate Territory of the United States in 1850, and its area was reduced to its present limits in 1863. In 1910 its population was 327,301, and the density of population was 2.7 to the square mile, having more than doubled since 1890. More than half the population are Mexicans, a people consisting partly of descendants of Mexican settlers of long ago and partly of descendants of local Indians with whom the Mexicans and others have intermarried. Spanish is the language of a large proportion of the population, and in many sections it greatly preponderates over English. A large number of Indians live in the several reservations in the State.

Of the 78,485,760 acres of New Mexico, nearly half is public land, 14,000,000 acres State land, 12,000,000 acres in ranches, 12,000,000 acres in private grants and Indian reservations, and 9,000,000 acres in national forests. Somewhat less than 2,000,000 acres is cultivated, and less than 600,000 acres is irrigated. Of the irrigated area 200,000 acres belongs to individuals or partnerships, 50,000 acres to commercial organizations, 300,000 acres to cooperative or community organizations, and 30,000 acres to Indians. The remainder is irrigated under Government reclamation, and the area so served will be considerably increased when the lands below the Elephant Butte Dam are utilized.

Probably the principal mineral resource of New Mexico is coal, which occurs in the large fields west of Raton, near Cerrillos, about Gallup, and in several minor areas. There are also mines of gold, copper, silver, lead, zinc, and a great variety of other minerals, clays, and building stones. The State contains also abundant supplies of underground water.

New Mexico contains many ruins of settlements of aborigines, some of them of great antiquity. There were large villages at many places long before the coming of the Spaniards, and irrigation was extensively practiced.

Just beyond the State line the train enters a tunnel half a mile long which extends under Raton Pass, at an altitude of 7,608 feet. For 30 years there was only one tunnel at this place, but a few years ago a second one was built. This pass is on the divide between the drainage basins of Arkansas River on the north and Canadian River on the south. The old Santa Fe Trail passed up the same canyon as the one followed by the railway and crossed through Raton Pass on the way south.

The mountain which is crossed at Raton Pass is not part of the main range of the Rocky Mountains, but is a lateral spur which extends eastward for 30 miles. Its height is due largely to the thick cap of lava which covers the high mesas east of the railway. This rock is so hard that it has resisted erosion and so maintained the high ridge. Doubtless the lava-covered mesa was originally much more extensive than it is at present, for the removal of the underlying sandstone and shales undermines the lava sheet, large blocks of which occasionally fall from the cliffs to the talus slopes below. The high mesa disappears about 35 miles east of Raton Pass, and the question is often asked, "Why doesn't the railway build around this high summit rather than go over it?" The principal reason is that the line was built to Trinidad to get the local coal, which does not extend far east of that place, and from Trinidad there is no feasible course other than that across the mountain. Another line is being built farther south, leaving the main line at Dodge, Kans., and 180 miles farther south is the Belen cut-off.

As the train emerges from the south portal of the Raton tunnel an extensive vista is presented. To the east stands the lava-capped Bartlett Mesa, and farther south are rolling plains lying far below the point of view and extending to the horizon. Toward the west is a mesa made up of the coal-bearing rocks, behind which rise the high peaks of the Culebra (coo-lay′bra) Range, a portion of the Rocky Mountains, with many lofty summits on which snow remains the greater part of the year. In the downgrade south to Raton the train passes rapidly across the coal-bearing rocks, then through a short gorge in the Trinidad sandstone, and finally out into the plain of Pierre shale on which the town of Raton is located. Good views of the lava-capped Bartlett Mesa to the east are presented at mileposts 654 and 655, the latter showing the great blocks of lava lying in a talus at the foot of the cliffs. Near milepost 654 there is an outcrop of coal on the east side of the track.

A short distance beyond milepost 658 the Pierre shale appears under a prominent cliff of the heavy Trinidad sandstone extending far to the east as well as to the southwest. Near milepost 659 there are extensive exposures of the Pierre shale west of the track, a fine view of Bartlett Mesa to the northeast, and a more distant view of the extensive Johnson Mesa, capped by lava, to the east.

Raton, N. Mex.
Elevation 6,622 feet.
Population 4,539.
Kansas City 674 miles.

Raton, the county seat of Colfax County, N. Mex., is the center of the mining industry of the coal field on the south side of the Raton Mountains, although no large mines are located in the immediate vicinity. There are several other industries in the region, especially stock raising and the production of wool. In the southern edge of the town brick and other clay products are manufactured from the Pierre shale. The Santa Fe Trail passed through Raton, then known as Willow Springs. The name Raton (Spanish pronunciation rah-tone′, locally pronounced rat-toon′) is Spanish for mouse. Goat Hill, which rises precipitously in the western edge of Raton, consists of Trinidad sandstone. About 6 miles due east is Johnson Mesa, a lava-capped table-land that rises to an altitude of about 8,000 feet and is similar to the Raton Mesa in structure. It is occupied by many ranches, for, owing to the high altitude, there is more rain and snow on this mesa than in the adjoining lowlands, and good crops are usually obtained.

Branch railways connect Raton with Yankee and Sugarite, two mining towns to the east, where coal is mined from beds lying a short distance above the top of the Trinidad sandstone. The mines of Colfax County produce about three-fourths of the coal output of New Mexico, which amounts to more than 3,700,000 tons a year, valued at nearly $5,000,000. The St. Louis, Rocky Mountain & Pacific Railway, a part of the Santa Fe system, has a branch running to Raton from Clifton House, a few miles to the south, parallel to the Santa Fe main line.

Dillon.

Elevation 6,456 feet.
Kansas City 678 miles.

From Dillon (see sheet 11, p. 66), 3 miles from Raton, a branch road extends up Dillon Canyon, in the mesa west of Raton, to coal mines at Blossburg and Brilliant. These mines were developed mainly to supply fuel for the railway and for many years yielded the greater part of the coal produced in the Raton field. Coke ovens at Gardiner, 3 miles southwest of Raton, still produce a large amount of coke, used in smelters in the Southwest. From Raton southward for many miles the mesa of Trinidad sandstone and overlying coal-bearing rocks is a prominent feature of the view.

Otero.

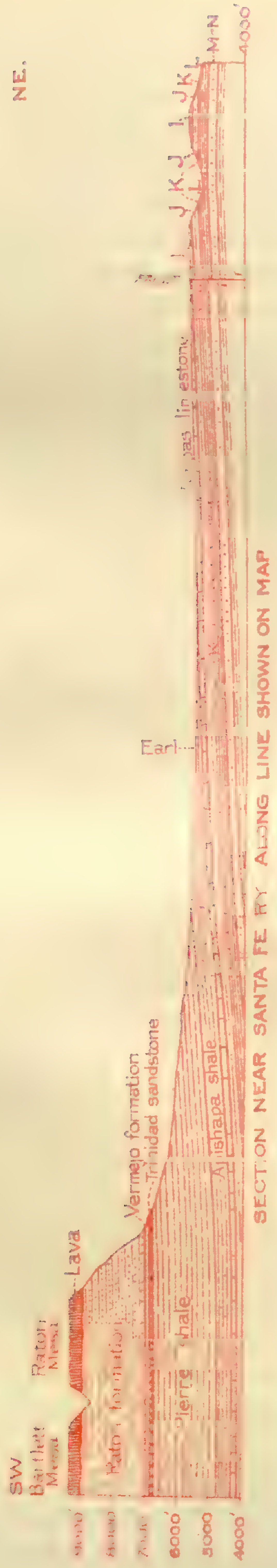
Elevation 6,378 feet.
Kansas City 680 miles.

Southwest of Otero (o-tay'ro), a siding 5 miles beyond Raton, the face of the mesa west of the railway is very precipitous, because it is formed of thick sheets of hard, igneous rock (basalt), which were intruded into the coal-bearing rocks in a molten condition. The heat of these intrusions has changed the coal into graphite in many places in an area of several square miles. These highlands culminate in Red River Peak, a prominent pinnacle 3 miles southwest of Otero, which in the early days of exploration served as an easily recognized landmark for the "prairie schooners" traveling the Santa Fe Trail. This trail, after passing through Raton Pass, came down the mesa a short distance north of Red River Peak, passed south near its foot, and went thence southwestward to Cimarron. The peak owes its prominence to the presence of a chimney-like mass of hard intrusive rock forced into the shale in a state of fusion. Beyond Otero the route crosses the St. Louis, Rocky Mountain & Pacific Railway, a line 94 miles long that lies wholly in New Mexico.

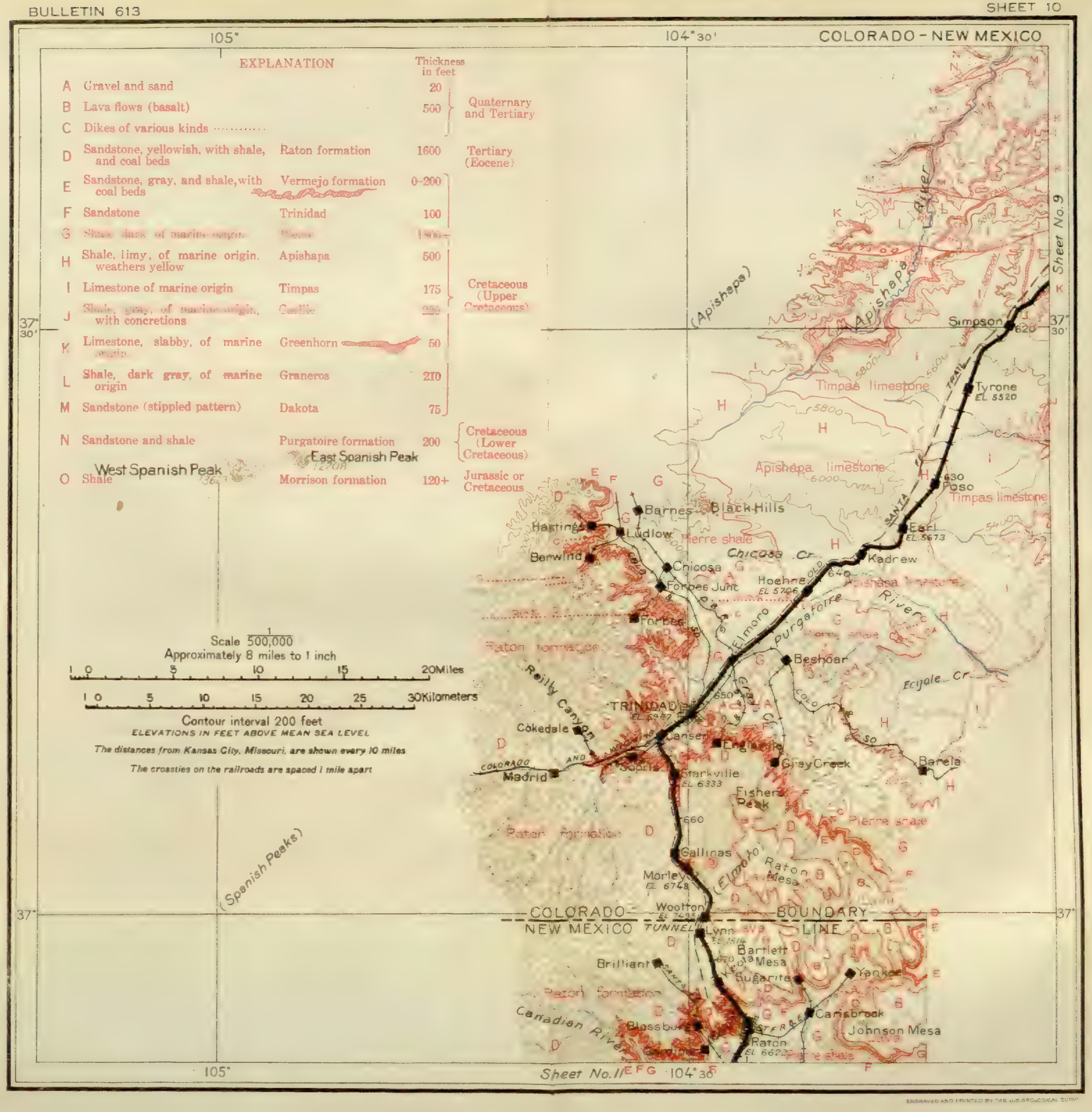
Hebron.

Elevation 6,156 feet.
Kansas City 687 miles.

A mile southeast of Hebron is a large storage reservoir covering 7,000 acres, to supply water to an extensive irrigated area about Maxwell. East of Hebron and Dorsey there are great masses of volcanic rocks constituting widespread platforms of moderate height, surmounted in places by high ridges and peaks, some of which were originally active volcanoes. One of the most conspicuous of these cones is Eagletail Peak, due east of Dorsey. Laughlin and Tinaja peaks are other prominent summits farther east. The sheet of dark



COLORADO - NEW MEXICO


105°
104°30'
37°30'
37°
EXPLANATION
Thickness in feet
A Gravel and sand 20
B Lava flows (basalt) 500 Quaternary and Tertiary
C Dikes of various kinds
D Sandstone, yellowish, with shale, and coal beds Raton formation 1600 Tertiary (Eocene)
E Sandstone, gray, and shale, with coal beds Vermejo formation 0-200
F Sandstone Trinidad 100
G Shale, dark, of marine origin Pierre 1800+
H Shale, limy, of marine origin, weathers yellow Apishapa 500
I Limestone of marine origin Timpas 175 Cretaceous (Upper Cretaceous)
J Shale, gray, of marine origin, with concretions Carlile 225
K Limestone, slabby, of marine origin Greenhorn 50
L Shale, dark gray, of marine origin Graneros 210
M Sandstone (stippled pattern) Dakota 75
N Sandstone and shale Purgatoire formation 200 Cretaceous (Lower Cretaceous)
O Shale Morrison formation 120+ Jurassic or Cretaceous
West Spanish Peak 13623
East Spanish Peak 12708
Scale 1/500,000
Approximately 8 miles to 1 inch
0 5 10 15 20 Miles
0 5 10 15 20 25 30 Kilometers
Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart
(Apishapa)
(Spanish Peaks)
Sheet No. 9
Sheet No. 11
Simpson
Tyrone EL 5520
Poso
Earl EL 5673
Kadrew
Hoehne EL 5706
Timpas limestone
Apishapa limestone
Apishapa River
Pierre shale
Raton formation
Barnes
Black Hills
Hastings
Ludlow
Berwind
Chicosa
Chicosa Cr.
Forbes Junc
Forbes
Elmoro
Purgatoire River
Beshoar
Trujillo Cr.
Reilly Canyon
Cokedale
TRINIDAD EL 5987
Sopris
Madrid
Starkville EL 6333
El Moro
Gray Creek
Barela
Fishers Peak
Gallinas
Morley EL 6748
Wootton EL 7433
Raton Mesa
COLORADO - NEW MEXICO BOUNDARY LINE
TUNNEL
Lynn
Bartlett Mesa
Brilliant
Sugarite
Yankee
Carisbrook
Johnson Mesa
Blossburg
Canadian River
Raton EL 6622
SANTA FE
COLO. AND SO.
ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

lava lies on the soft Pierre shale, and at some places its margin presents a cliff showing more or less columnar structure. This cliff exists because in most places the original thin margin of the lava flow has been removed by erosion and the thick mass of lava, with its characteristic columnar structure is exposed.

In the region extending from Raton Mesa to these volcanic peaks there has been prolonged volcanic activity in several separate epochs. The caps on the high mesas are remnants of the earliest flows, poured out before the surrounding lowlands had been excavated. After these outflows ceased erosion progressed, developing valleys and cutting away a portion of the earlier lava sheets. Then followed eruptions of lava, mostly from new vents, which spread out over the lower lands. This was repeated at least three times, and between successive outflows the valleys were considerably deepened. The last eruptions were very recent, for they closed with the building of cinder cones that are still steep-sided and have central craters apparently as fresh as if they had just cooled off. Eagletail and other smaller cones are visible from the railway; others can not be seen, but the largest, Mount Capulin, is only 20 miles east of Hebron.

Dorsey.

Elevation 5,885 feet.
Kansas City 691 miles.

From Hebron to and beyond Dorsey the line of cliffs to the west continues to be a conspicuous feature. As explained above, these cliffs mark the outcrop of the Trinidad sandstone at the base of the coal-bearing rocks. They gradually trend away toward the southwest, however, and near Maxwell are 15 miles from the Santa Fe line.

Maxwell.

Elevation 6,063 feet.
Population 395.*
Kansas City 701 miles.

Several railways that lead to the coal fields beyond the cliffs on the west cross the Santa Fe line south of Raton. One from Dillon to Blossburg and another south of Otero have been mentioned; a third goes from Hebron to Van Houten, and the fourth is a branch of the El Paso & Southwestern system, which crosses at French, affording an outlet from the extensive mines and coke ovens at Dawson. In the Stag Canyon mine at Dawson, on October 22, 1913, occurred one of the most disastrous coal-mine explosions ever known in the West, causing the death of 263 men. This happened in a completely equipped mine, in which all precautions had been taken by the management, but disregard of regulations by the miners caused coal dust to become ignited, and an extensive explosion followed.

French.

Elevation 5,784 feet.
Kansas City 706 miles.

The valley followed by the railway from Dillon to French is that of Canadian River, which rises in the hills west of Raton and flows into Red River in southern Oklahoma. This stream was originally called Red River, on the supposition that it was the head of the Red River of Louisiana and Arkansas, a mistake finally rectified through explorations by Capt. Marcy, who discovered that the headwaters of the much shorter but so-called main branch of Red River are far to the southeast, in northwestern Texas.

The Canadian River valley is broad from Otero southward because it is excavated in the soft Pierre shale, which crops out in a wide zone across this portion of northern New Mexico. This shale is exposed here and there in shallow cuts along the railway. South of French the Timpas limestone is crossed, but its outcrop is hardly noticeable from the trains. From this point southward are shales which probably represent the upper formation (Apishapa shale) of the Niobrara group.

Springer.
Elevation 5,768 feet.
Population 550.
Kansas City 715 miles.

The town of Springer is built on the north bank of Cimarron Creek, a running stream of moderate size, which rises in the Rocky Mountains 35 miles west. This creek is an entirely different stream from Cimarron River, which rises a few miles east of Raton and flows through Oklahoma. Cimarron Creek passes through the village of Cimarron, on the Santa Fe Trail 20 miles northeast of Springer, and empties into Canadian River a few miles east of Springer.

A short distance below the juncture of Cimarron Creek and Canadian River is the beginning of the long, deep canyon which the Canadian cuts into the Dakota sandstone and underlying red beds. The water of the Cimarron, which has an average volume of 14 to 25 second-feet, is used for the irrigation of 30,000 acres in the wide plains from Springer west to Cimarron Village. Formerly this region was entirely devoted to the cattle industry; now it is producing large crops of alfalfa, wheat, beans, potatoes, corn, oats, barley, and peas. Its fruit season begins in July with cherries, continues with apricots, plums, peaches, and pears, and ends in October with apples.

A short distance south of Springer there are extensive exposures of the Timpas limestone in stream and railway cuts. Some years ago an attempt was made to utilize this rock for the manufacture of cement, but the project was not successful, and the old kilns are all that remain of the enterprise. The limestone is in beds mostly from 6 to 20 inches thick, alternating with thin layers of black shale. The rocks contain marine shells that are distinctive of the deposits of that period in this part of the intracontinental seas.[1]

To the south and west of this place are extensive exposures of overlying shales supposed to represent the Apishapa shale. They give rise to low but conspicuous buttes to the west and finally grade up into well-defined Pierre shale.

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[1] In this region the Timpas limestone is underlain by 250 feet of unmistakable Carlile shale, extending to the top of characteristic Greenhorn limestone, which is extensively exposed in the banks of Cimarron Creek a few miles east of Springer. There are cuts in Timpas limestone at intervals as far south as milepost 704, where 6 feet of beds are exposed in layers 12 to 18 inches thick.

A. ALLOSAURUS.

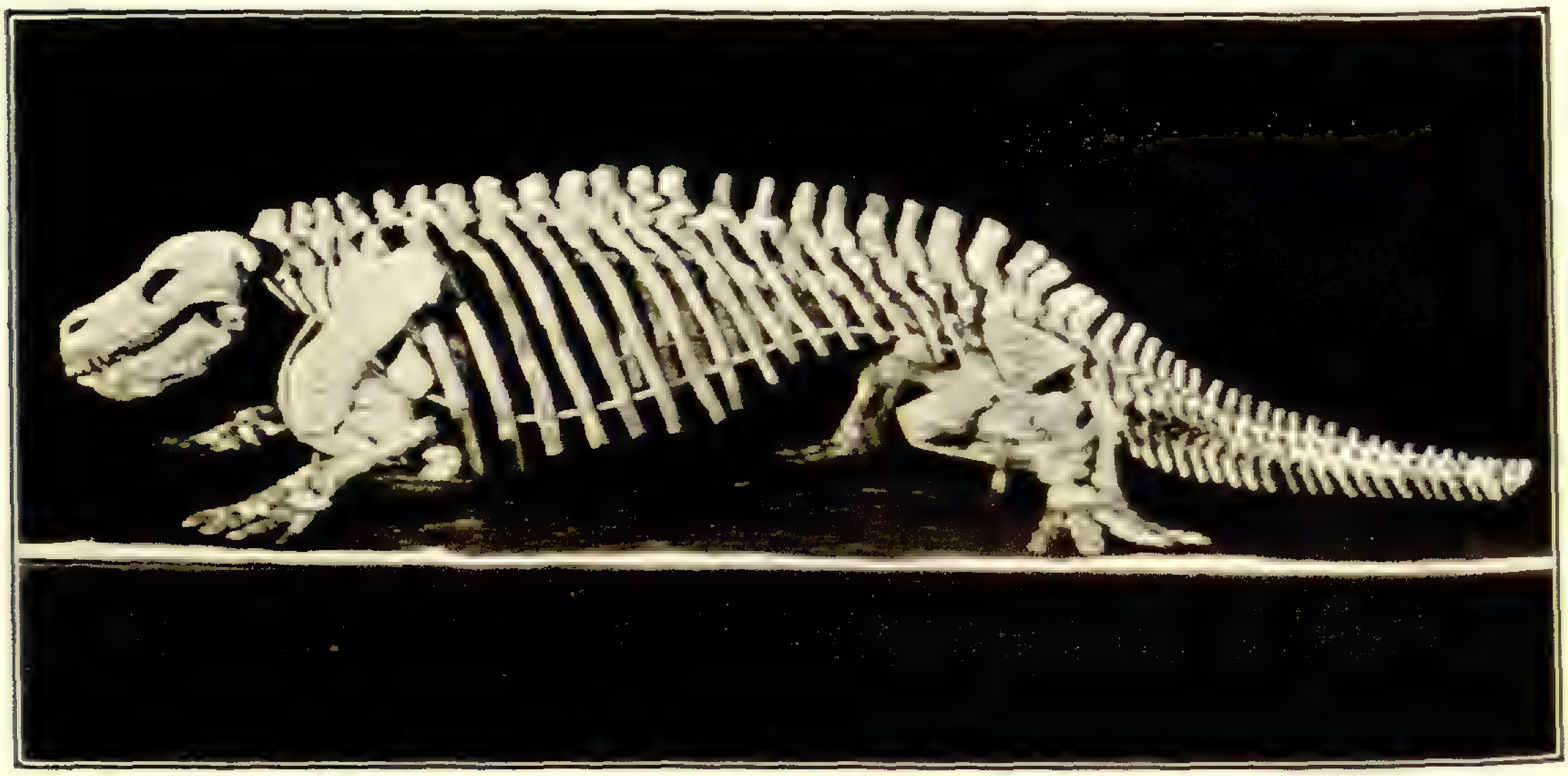
A great carnivorous dinosaur or megalosaurian. Restored by Charles R. Knight from bones found in the Morrison formation, Colorado.

B. STEGOSAURUS.

A huge lizard that lived at the time of the deposition of the Morrison formation. Restoration by Charles R. Knight.

A. BRONTOSAURUS.

A great amphibious dinosaur from horizon of Morrison formation, Wyoming. Restoration by Charles R. Knight.



B. SKELETON OF DIADECTES.

A reptile that lived in the Southwest at the time the red beds were deposited. From the Wichita formation (lower Permian) of Texas. Specimen in American Museum of Natural History, New York City.

Rayado.
Elevation 5,971 feet.
Population 103.*
Kansas City 721 miles.

At Rayado the front of a high mesa is conspicuous about 8 miles west of the railway. It is capped by lava (basalt) and is an outlying portion of a widespread sheet of lava that caps the broad mesa or plateau to the south and west.

Colmor.
Elevation 5,924 feet.
Population 224.*
Kansas City 725 miles.

South of Colmor the line gradually approaches the east end of this plateau and at Wagon Mound passes through a gap in it. The mesas in this vicinity are not as high as those at Raton Pass, but as they rise several hundred feet above the adjoining plains they are prominent topographic features. Near Wagon Mound the lava is at two levels, representing two stages of outflow, but that at the lower level is of small extent. The lava covering the higher mesas came from vents to the west, probably in large part from the Ocate (o-cah′tay) volcanic cone, the location of which is shown on sheet 11 (p. 66).

Wagon Mound.
Elevation 6,177 feet.
Population 1,983.*
Kansas City 741 miles.

Wagon Mound is one of the old settlements on the Cimarron branch of the Santa Fe Trail, which came southwestward from a point near Dodge, Kans. Two monuments a few rods east of the railway station show the line of the old highway. This branch of the trail crossed the line of the railway a short distance south of the station and passed southwestward to Fort Union, where it joined the other branch, which came through Raton and Cimarron and over the volcanic mesa west of Colmor and Wagon Mound. For a long time there was a Mexican customhouse at this place. Its name is derived from the resemblance of one of the peaks near by to a wagon top, when seen from points far to the northeast.

The relations of the two lava sheets are well exposed about Wagon Mound. The higher sheet reaches many miles west and northwest, as well as along the top of the narrow ridge extending 11 miles east of the village. This sheet is about 100 feet thick and lies on a platform of Pierre shale that was originally the floor of the valley down which the lava flowed. Subsequent erosion has cut away the adjoining lands to much lower levels and considerably diminished the extent of the lava sheet by undermining its edges. These edges now present steep cliffs, in places exhibiting columnar structure and having at their bases talus or piles of loose fragments. The softness of the underlying shale greatly facilitates the breaking down of the edges of the lava sheets, and in places there are extensive landslides where huge slivers of the hard lava have been let down in this way.

Leaving Wagon Mound the train passes across a narrow tongue of the lower lava flow and a short distance farther south crosses a wide valley from which there are excellent views of the high lava-capped mesas to the north. The high ridge known as the Turkey Mountains is a prominent feature west of Bond. (See sheet 12, p. 72.) It is due to a dome-shaped uplift of the rocks which in the center exposes an extensive area of red beds and underlying limestones of Carboniferous age. The light-gray foothills are the outcrop of the upturned edges of the Dakota sandstone.

For some distance south of milepost 730 the Greenhorn limestone is near the track, and finally, as it is crossed by the railway, it is exposed extensively in cuts, notably between mileposts 732 and 734. A short distance beyond milepost 734 the route descends from the flat ridge of the limestone into a broad area of lava (basalt). This lava came from the Maxson Crater, an irregular volcanic cone which is visible on the southeast slope of the Turkey Mountain uplift, 5 miles west of Optimo (op′tee-mo). The lava flowed down slopes of Dakota sandstone, then across the broad flat which is now traversed by the railway from Optimo nearly to Shoemaker, and finally down the canyon of Mora River nearly to its mouth, 20 miles to the southeast. The flow is moderately recent and exhibits a variety of features characteristic of the later basalt flows. Its surface is considerably blistered, and much of the rock is vesicular or spongy, with small cavities due to the escape of steam.

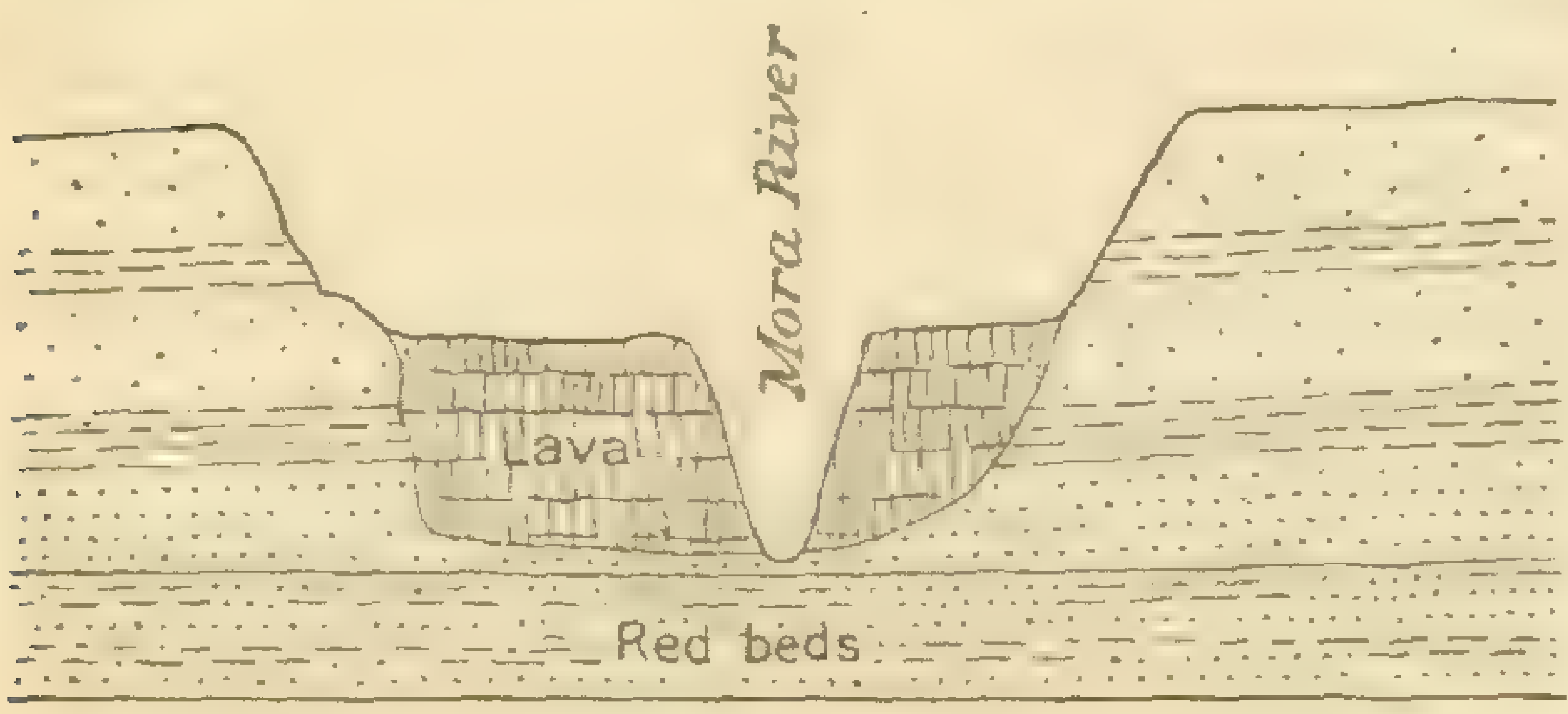


FIGURE 10.—Section across canyon of Mora River southeast of Optimo, N. Mex., showing relations of lava flow, looking east. The total depth of the canyon is about 700 feet.

Optimo.

Elevation 6,365 feet.
Kansas City 751 miles.

In the broad valley south of Optimo the lava spread out widely, but in flowing down the deep canyon of Mora River it was narrowed to a few hundred yards. It filled this canyon about halfway up its sides, but the river has since cut a narrow inner gorge into the lava sheet and in places through the lava into underlying rocks, as shown in figure 10. This lava-filled canyon begins 6 miles east of the railway, and its outer walls of sandstone are plainly visible from the vicinity of milepost 740.

Shoemaker.

Elevation 6,256 feet.
Kansas City 758 miles.

Halfway between mileposts 741 and 742 the southern margin of the lava sheet abuts against a cliff of Dakota sandstone which extends northwestward. A short distance beyond this place, near Shoemaker, the bank of Mora River is reached, and the railway follows this stream along the north side of the deep canyon which it has cut in the Dakota sandstone and underlying beds. The beds lie nearly horizontal and in places the high cliffs of sandstone have at their bases the greenish-gray shale of the underlying Morrison formation. On the north side of the track at milepost 748 the Dakota sandstone is extensively quarried for railway ballast. Two miles beyond there is, on the south

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
SANTA FE ROUTE
From Kansas City, Missouri, to Los Angeles, California

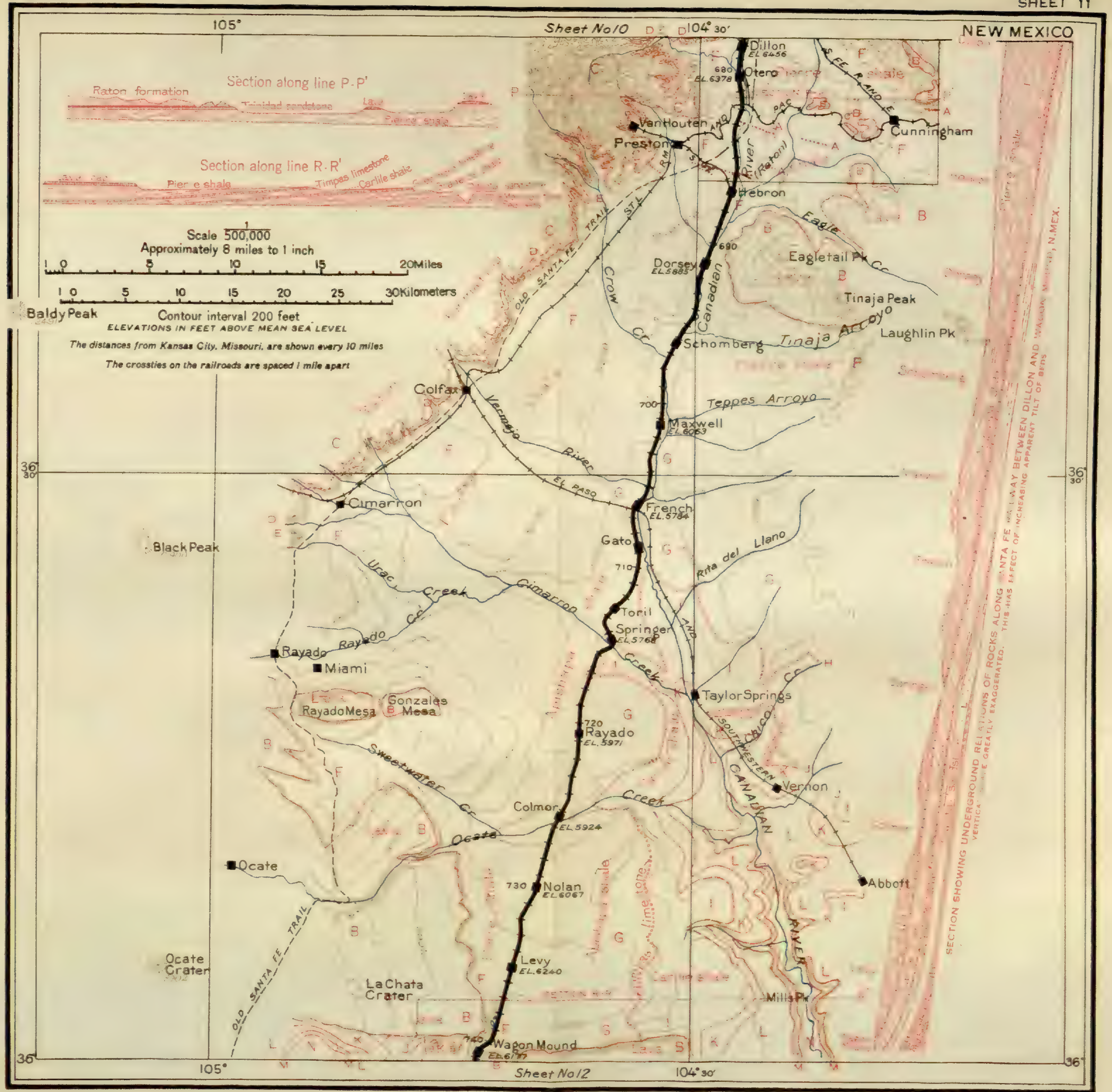
Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist
R. B. Marshall, Chief Geographer
1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.

EXPLANATION

			Thickness in feet	
A	Dikes (basalt, etc.)			Quaternary ?
B	Lava flows (basalt, etc.)			Quaternary and Tertiary
C	Sandstones and shales; coal	Raton formation	1600±	Tertiary (Eocene)
D	Sandstone, shale, and coal	Vermejo formation	0-175	
E	Sandstone	Trinidad	100	
F	Shale, dark, of marine origin	Pierre	2250	
G	Limy shale of marine origin	Apishapa	500	Cretaceous (Upper Cretaceous
H	Limestone of marine origin	Timpas	50	
I	Shale with concretions, of marine origin	Carlile	250	
J	Limestone, slabby, of marine origin	Greenhorn	60	
K	Shale, dark, of marine origin	Graneros	150	
L	Sandstone	Dakota and Purgatoire	200	Cretaceous (Upper and Lower)
M	Shales, mostly pale green	Morrison formation	150	Jurassic or Cretaceous
N	Shales and sandstone, both red	"Red Beds"	1000+	Triassic ? and Carboniferous



bank of the river, a bluff of Dakota sandstone, with Morrison shale[1] at its base.

Watrous.

Elevation 6,398 feet.
Population 336.*
Kansas City 766 miles.

Watrous is the railway town for extensive cattle, sheep, and other interests. It dates back to the time of the Santa Fe Trail, the Cimarron branch of which passed through the western portion of the village. Eight miles north are the ruins of Fort Union, one of the most important military stations on the Santa Fe Trail, where the two principal branches of the trail from the north joined. The place may be seen far to the north from points a short distance beyond Watrous. The adobe houses are unroofed, most of the walls are falling into ruins, and the grounds are overgrown with grasses, but the visitor may see that the fort had accommodations for a large garrison. This fort served not only as a refuge for the settler and the traveler, but its storehouse and arsenal carried a large stock of Army supplies. Its possession was the strategic object in the Civil War in the far West. To its protection Union volunteers rushed over the snowy mountains from Denver, while Confederate troops marched a thousand miles from Texas to take it. Only the defeat of the Texas soldiers at Glorieta Pass prevented the Confederates from capturing the Army supplies and ammunition stored in Fort Union.

In the vicinity of Watrous there are wide alluvial flats that have long been utilized for farming, mainly by the assistance of irrigation from Mora River and a branch stream, Sapello Creek. The Mora drains a portion of the east slope of the Rocky Mountains. Gagings by the United States Geological Survey at La Cueva (kway′va), 15 miles above Watrous, found that its average flow was 29 second-feet in 1909 and 20.3 second-feet in 1910.

On the south side of the track three-fourths of a mile beyond Watrous is a large quarry for obtaining massive blocks of Dakota sandstone, which are used for making embankments along portions of the railway as a protection from washouts.

East of the railway at milepost 753 is a granite monument marking the location of the Santa Fe Trail from Fort Union to Las Vegas. Its course was very nearly the same as that now followed by the railway. A short distance beyond Kroenigs siding the upgrade of the railway carries it from the Dakota sandstone to the Graneros shale[1] and thence within 2 miles to the summit of an extensive plateau of Greenhorn limestone, above which to the west rise buttes of Carlile shale. This plateau is the divide between the drainage basin of Mississippi River and that of the Rio Grande. A fine vista of the Rocky Mountains is afforded toward the north and west; due west is Solitario Peak, a knob of granitic rocks rising to an altitude of 10,200 feet, and farther northwest are still higher peaks near the center of the range. The Turkey Mountains and Ocate Crater are conspicuous toward the northeast.

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[1] During the time of deposition of the clays constituting the Morrison formation there existed a great variety of remarkable reptiles of huge size. Restorations of some of them are shown in Plates X and XI (pp. 64, 65), based on bones exhumed from the formation in southern Colorado. These bones, which are in places abundant, are the remains of animals that were mired in the soft clay of which the Morrison formation largely consists. Some of these creatures, such as the Brontosaurus (Pl. XI, *A*), were 60 feet long. Many of them had remarkably small heads, notably the Stegosaurus (Pl. X, *B*), which had such a diminutive brain that it must have been very stupid. This animal was undoubtedly very clumsy also, but its huge size and protective armor aided in its preservation.

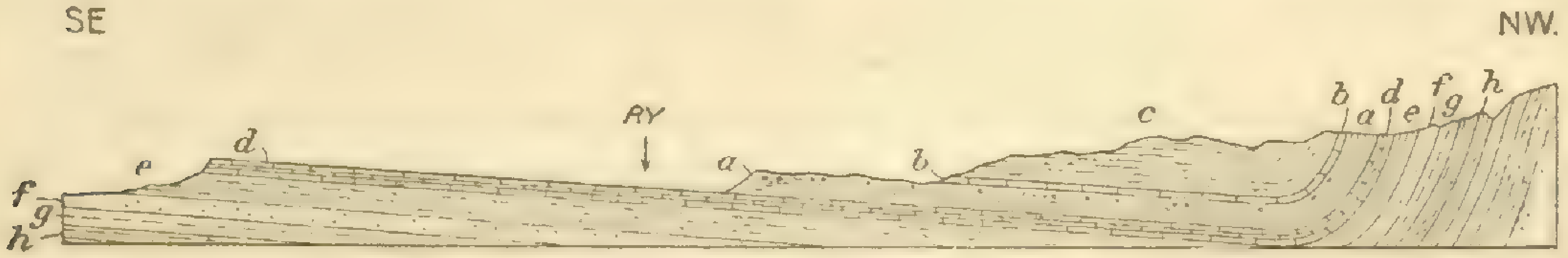

FIGURE 11.—Section 6 miles north of Las Vegas, N. Mex., looking southwest. *a*, Carlile shale; *b*, Timpas limestone; *c*, Apishapa (?) and Pierre shales; *d*, Greenhorn limestone; *e*, Graneros shale; *f*, Dakota sandstone and Purgatoire formation; *g*, Morrison formation; *h*, red beds.

Onava.
Elevation 6,730 feet.
Kansas City 775 miles.

Onava is a small settlement sustained by irrigation with water brought through canals from streams and reservoirs a few miles to the northwest. From Onava southwestward the railway runs on a gentle down grade to Las Vegas, all the way on the surface of the Greenhorn limestone, except where it is covered by a thin capping of the Carlile shale. The bed dips gently to the west and southwest, so that the surface of the plateau is in greater part a dip slope of the limestone. This rock is exposed in many railway cuts, especially near Las Vegas, and to the west at varying distances is a line of buttes of the overlying Carlile shale. The relations of the rocks near Onava and along a line passing through Las Vegas are shown in figures 11 and 12.

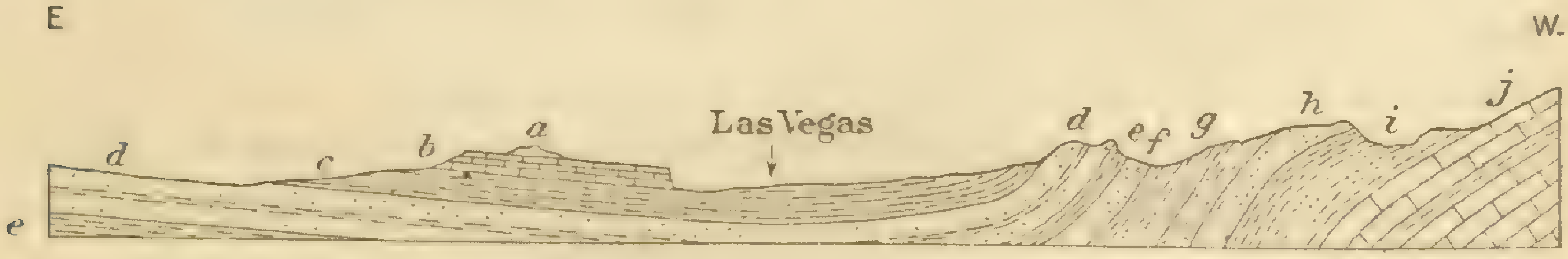

FIGURE 12.—Section through Las Vegas, N. Mex., looking south. *a*, Carlile shale; *b*, Greenhorn limestone; *c*, Graneros shale; *d*, Dakota and Purgatoire sandstones; *e*, Morrison shale; *f*, massive sandstone, capped by thin limestone; *g*, red shales and sandstones; *h*, sandstone in middle of red beds; *i*, lower red beds; *j*, Magdalena limestone.

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[1] A contact of these rocks is well exposed at a point half a mile west of Kroenigs siding. To the south and west of this place is a low ridge of the Greenhorn limestone, which overlies the Graneros shale. All the beds in this vicinity lie nearly level or dip at a low angle to the west.

Las Vegas.

Elevation 6,384 feet.
Population 6,934.
Kansas City 786 miles.

Las Vegas (vay′gas) is a railway division point where all the trains stop, most of them for meals at the Castañeda (cas-tahn-yay′da), a hotel named for the young soldier who accompanied Coronado's expedition and wrote the narrative of it. The Santa Fe Railway reached Las Vegas in 1879 but continued building rapidly to the south. The portion of Las Vegas near the railway is relatively modern; the "old town," or original Mexican settlement on the Santa Fe Trail, is some distance west of the station. The name is Spanish for the meadows. On the flat roof of a building in Las Vegas Gen. Kearney stood in 1846 to administer to the Mexican citizens the oath of allegiance to the United States. Five years before that the plaza of Las Vegas was the scene of a great celebration over the surrender of the various detachments of Texans who had entered New Mexico to induce the inhabitants to join the Texas Republic. Gallinas Creek, which flows through Las Vegas, is a small stream draining a portion of the east slope of the Rocky Mountains. Gagings by the United States Geological Survey have shown that its average flow is about 23 second-feet. The water is utilized for irrigation.

A branch railway goes northwestward from Las Vegas, 6 miles to the Montezuma Hot Springs in a gap in the foothills where there is a large hotel and sanitarium that, in recent years, has not been open.

Most of Las Vegas is built on the Greenhorn limestone, and this formation also crops out extensively in the high bluff just east of the railway station, where all its beds may be seen. At the base, near the stream, is the underlying Graneros shale, passing upward by a few feet of transition beds into the Greenhorn limestone. This limestone presents its usual characteristic features of an alternation of many thin beds of nearly pure limestone and dark shale. In some of the shale and in a few beds of the limestone there are abundant impressions of the characteristic fossil *Inoceramus labiatus*, a mollusk with oval shell somewhat similar to the oyster. The thickness of the Greenhorn limestone in these exposures is fully 100 feet, and the top of the formation constitutes a mesa extending some distance east to low hills of Carlile shale which rise above it.[1]

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[1] A short distance north of Las Vegas the Greenhorn limestone passes under the Carlile shale, a formation which carries numerous round concretions in its upper portion. This is overlain by a thick body of shale representing the Niobrara group and Pierre shale and occupying a basin which pitches to the north and the beds on the western edge of which are steeply upturned along the foothills. In these foothills a short distance west of Las Vegas, and especially in the canyon near the hot springs, are extensive outcrops of the succession of rocks underlying the Greenhorn limestone, comprising the Graneros shale, Dakota and associated sandstones, Morrison formation, "Red Beds" of Triassic and Carboniferous age, and older Carboniferous limestones, all standing nearly vertical on the east side of the great mass of granites and schists of the main Rocky Mountain uplift.

A few miles east of Las Vegas the plateau or bench of the mountains on which it is situated terminates in a great vertical escarpment of Dakota sandstone, which overlies the Morrison formation. This escarpment overlooks the Canadian and Pecos valleys, which lie between the Las Vegas Plateau and the western edge of the Staked Plains of Texas.

At Las Vegas an extra engine is attached to haul the train up the heavy grades of the long climb over the south end of the main chain of the Rocky Mountains, which lies between Las Vegas and Lamy. In order to find suitable grades for crossing this range it was necessary to deflect the railway line far to the south, for in the country west and northwest of Las Vegas the lowest passes through the mountains are at altitudes greater than 10,000 feet, or more than 2,500 feet higher than Glorieta Pass, the one utilized.

On leaving Las Vegas, the train goes southward, at first over a rolling plain of the Graneros shale along Gallinas Creek (gahl-yee′nas; locally gah-yee′nas). Within 2 miles the base of this shale is reached, and the underlying Dakota sandstone appears in railway cuts and in the canyon a short distance east of the track. Half a mile beyond is a shallow basin of the shale, in which small outliers of the overlying Greenhorn limestone rise as hills on both sides of the track.

Romero.
Elevation 6,287 feet.
Kansas City 791 miles.

Just west of Romero (ro-may′ro) siding the railway turns west into a gap through a "hogback" ridge that constitutes one of the foothills of the mountains. This hogback consists of Dakota sandstone and associated rocks steeply upturned on the east side of the uplift of the main range of the Rocky Mountains. The ridge is caused by the hardness of the upturned beds, which resisted to some extent the elements that eroded to a lower level the soft overlying shale on the east and the red shales on the west. The hogback ridge extends far to the north along the foot of the mountains, but toward the south, where the dips become gentler, it finally merges into a plateau presenting steep cliffs to the west and south, which are visible east of the railway for several miles.

Beyond the hogback ridge the railway goes southward up a valley of red shale, but in places it bears westward through gaps in several small ridges caused by layers of sandstone included in the red shale. The manner in which these sandstones give rise to small ridges is an instructive illustration of the relation of hard and soft rocks to the topography. The hard layers vary in thickness, but all make ridges of greater or less prominence. To the west of the railway there rises out of the red shale valley a bed of hard sandstone of considerable thickness, which constitutes a high ridge extending for many miles north and south parallel to the hogback ridge. The relations of these rocks are shown in figure 13, a section across the railway in the vicinity of milepost 779, half a mile beyond Ojita siding. The Spanish word ojita (o-hee′ta) means little spring.

The sandstone in the ridge west of the railway is thick and hard, and is a persistent member in the middle of the great succession of red beds throughout this region. It is crossed by the railway in a sharp turn to the west at milepost 785, at the bridge over Tecolote (tay-co-lo′tay) Creek.

From this place westward the surface of the sandstone is traversed for some distance. On some of the higher mesas adjoining the track the overlying red shales remain.

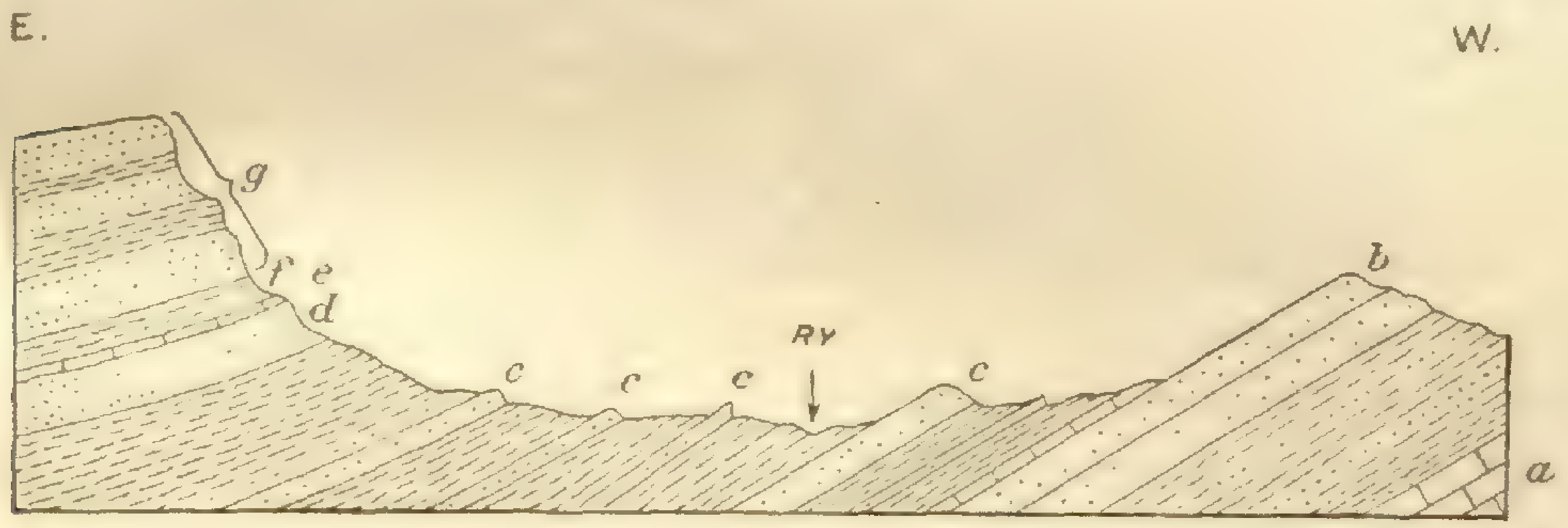

FIGURE 13.—Section across the east slope of the Rocky Mountain uplift near Ojita, 8 miles southwest of Las Vegas, N. Mex. *a*, Limestone of Magdalena group; *b*, thick, hard buff sandstone; *c*, beds of hard sandstone in red shale; *d*, Triassic sandstone; *e*, gray shale (Morrison); *f*, Purgatoire formation and Dakota sandstone.

Chapelle.

Elevation 6,068 feet.
Kansas City 805 miles.

At Chapelle there are long slopes of the hard sandstone. A mile beyond Chapelle the old Mexican plaza of Bernal (bare-nahl′) is passed a short distance north of the railway. Near by, at Bernal Springs, the Colorado volunteers camped in 1862 before their successful battle with the Texans, who were fresh from victory over the Federal troops at Valverde and encouraged by their easy occupation of Albuquerque and Santa Fe. A mile south of Bernal rises the well-known landmark Starvation Hill, a butte capped by a thick mass of the hard sandstone above referred to. This butte was the refuge of a party of Spaniards pursued by Indians, and it is stated that they were kept on the hill until they finally starved to death. There is a cross on the top, erected by the Penitentes, of whom there are many among the Mexican residents of this region. The butte is an outlier of a high mesa to the south, which consists of a widely extended platform capped by the hard sandstone that extends along the railway east of Chapelle, here carried to considerable height by the upward rise of the strata. Owing to the hardness of the capping rock and the softness of the underlying red shale the mesa presents a very precipitous outward slope toward the north.

In passing along the foot of this mesa the railway is on the lower red beds for a short distance and then from milepost 792 to 794 on the still lower limestone of the Magdalena group,[1] of Pennsylvanian age, which is exposed in many of the railway cuts.

Ribera.
Elevation 6,019 feet.
Kansas City 815 miles.

Just beyond Ribera (ree-bay′ra) the railway crosses Rio Pecos (pay′cos), a large stream which rises in the south end of the Rocky Mountains, flows across eastern New Mexico and the western part of Texas, and finally empties into the Rio Grande. This is the first important stream of the Rio Grande drainage basin met in the westward journey, although Gallinas and Tecolote creeks, above referred to, are in the Pecos basin. According to gagings by the United States Geological Survey at Cowles, 20 miles or more to the north, the flow of this river averages about 100 second-feet. The water is used for irrigation at many places. There are many Mexican settlements along Rio Pecos. One of these, San Miguel (me-gale′), is a large plaza plainly visible from Ribera station, about a mile to the south, and another, San Jose (ho-say′), formerly an Indian village, is a short distance east of milepost 802. It was at San Jose that Gen. Kearney and the Army of the West encamped in 1846, expecting the next day to have a battle with 2,000 Mexicans under Gov. Armijo (ar-me′ho), who were reported to be waiting for them in the canyon beyond the summit. The following day near Pecos they learned that the Mexicans, after constructing elaborate breastworks, had quarreled among themselves, and the governor and his forces had discreetly retreated, leaving the way to Santa Fe open to the Americans.

It will be noted that most of the houses of the Mexican settlements are built of adobes (ah-doe′bays), which are large bricks made of sun-dried earth.[2] The roofs and in some houses also the framework are made of juniper posts, and the better houses are plastered. Houses of this sort are warm in winter and cool in summer.

Fulton.
Elevation 6,526 feet.
Kansas City 823 miles.

South of Sands and Fulton is a high plateau known as Glorieta Mesa, the northeastern foot of which is followed by the railway to Glorieta (glo-reeay′ta). This mesa presents toward the northeast a continuous line of cliffs, with level crest, surmounting long slopes which descend to the valley of the Pecos. The railway is built along this slope on an irregular shelf or series of shelves due to various sandstone beds in the lower part of the red bed series. Glorieta Mesa is

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[1] This limestone is a light-colored massive rock containing numerous impressions of marine shells and is brought up in a low arch along a prolongation of one of the axes of the main Rocky Mountain uplift. It is about 1,000 feet thick and is underlain directly by the old granites and schists which may be seen in the high ridges beginning 4 or 5 miles north of milepost 794. At this milepost the railroad is on the lower portion of the red beds again, and these continue for several miles west.

[2] In the West the term adobe is commonly used both for the material from which the bricks are made and for a house built of them.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
SANTA FE ROUTE
From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

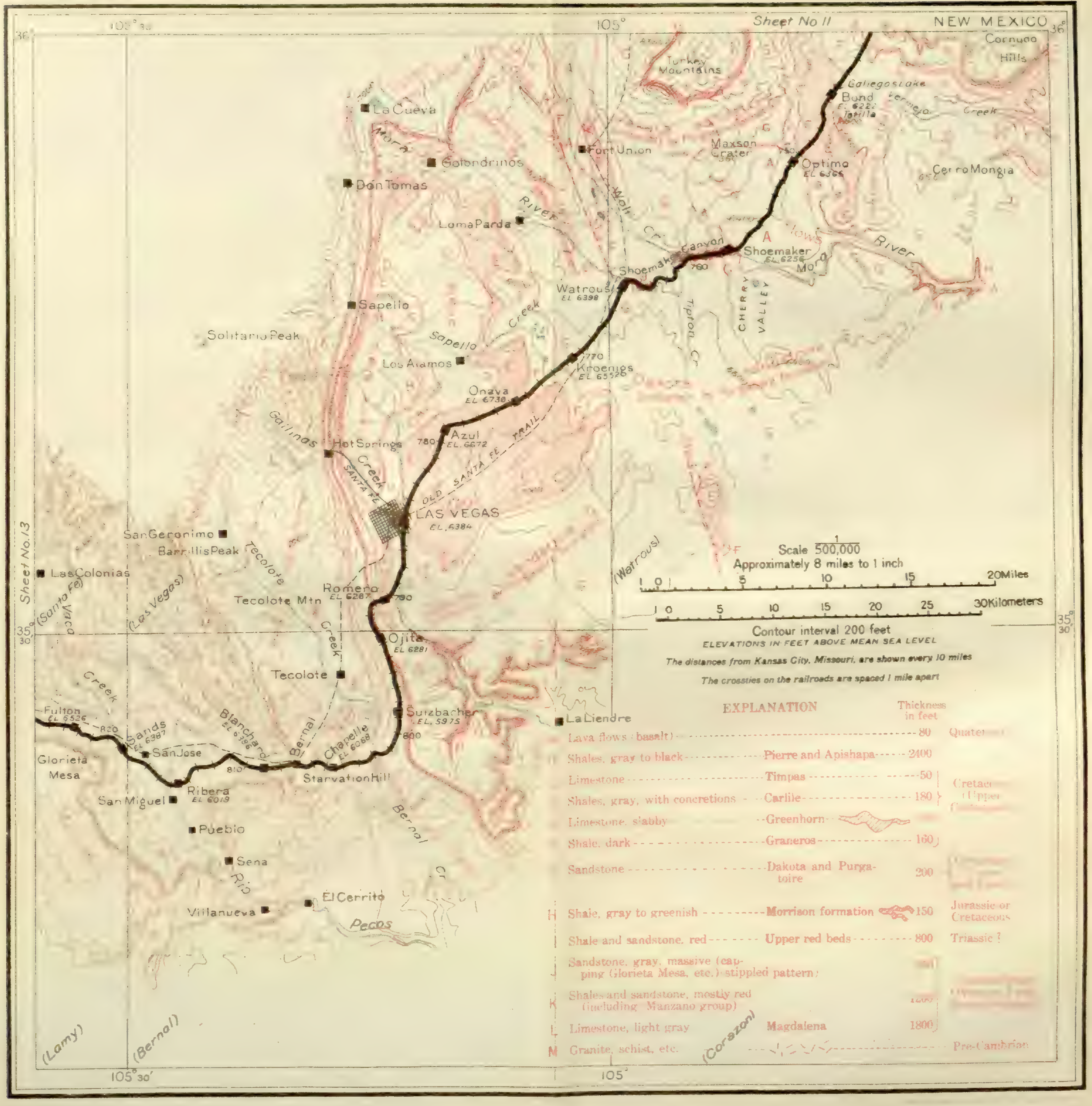
UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.



EXPLANATION

			Thickness in feet	
	Lava flows (basalt)		80	Quater
	Shales, gray to black	Pierre and Apishapa	2400	
	Limestone	Timpas	50	Cretac (Upper
	Shales, gray, with concretions	Carlile	180	
	Limestone, slabby	Greenhorn		
	Shale, dark	Graneros	160	
	Sandstone	Dakota and Purgatoire	200	
H	Shale, gray to greenish	Morrison formation	150	Jurassic or Cretaceous
I	Shale and sandstone, red	Upper red beds	800	Triassic ?
J	Sandstone, gray, massive (capping (Glorieta Mesa, etc.) stippled pattern)			
K	Shales and sandstone, mostly red (including Manzano group)			
L	Limestone, light gray	Magdalena	1800	
M	Granite, schist, etc.			Pre-Cambrian

capped by the gray to buff sandstone of the same bed which caps Starvation Hill and the mesa southwest of Chapelle.

At Pajarita (pah-ha-ree′ta), a small Mexican settlement north of the railway, 3 miles beyond Gise siding (see sheet 13, p. 88) and for a mile or two west of that place, the railway is on or near the top of the Magdalena, the same limestone as that which is exposed between mileposts 792 and 794. This limestone is deeply trenched by the Rio Pecos, which flows in a deep canyon 1 to 2 miles north of the railway in the vicinity of Pajarita and Rowe. The high mesa cuts off the view to the south, but there is in this region an extended vista to the north up the valley of the Rio Pecos and along the many rocky ridges constituting the southern extension of the Rocky Mountains.

Rowe.
Elevation 6,805 feet.
Population 358.*
Kansas City 831 miles.

A short distance beyond milepost 819, 3 miles north of Rowe, the remains of Old Pecos Church are visible about 2 miles north of the railway, and they continue in sight to and beyond Decatur siding, 1 mile beyond milepost 820. They are shown in Plate XII, *A* (p. 74). These ruins mark the site of the old pueblo of Cicuye (see-koo′yay), which occupied a large area on the top and slopes of a long low ridge of red sandstone.

The traveler is now entering the land of the Pueblo Indians, who have an interesting history, extending back many centuries. The name Pueblo (pweb′lo) was applied to them by the earliest explorers because they lived in well-established permanent villages (pueblos in Spanish), in marked contrast to the transient camps of the nomadic tribes to the east and west. With the Spanish conquerors and after them came many self-sacrificing missionaries and other colonists from Mexico and Spain, endeavoring to civilize the Pueblo people. It is not easy to-day to appreciate the heroism of the men who so bravely entered this strange and isolated country and ruled its natives for 300 years. There were many struggles and massacres, and the early chronicles are touching in their evidence of a religious zeal that overcame severe privations.

At the time of Coronado's march of conquest there were reported to be 71 pueblos in New Mexico and eastern Arizona, but numerous remains of habitations of this character show that originally there were many more of them and that they occupied a much wider territory in ancient times. In the seventeenth century the missionaries endeavored to concentrate the Pueblo people into fewer settlements, not alone to strengthen them against attacks from the savage nomadic tribes, but also to facilitate their conversion to Christianity. The revolt of the Pueblo people against Spanish authority, in 1680 to 1692, caused the abandonment of still more pueblos. Only about 20 pueblos are now occupied, and of these only Acoma and possibly Isleta (ees-lay′ta) are on the same sites as before the revolt of 1680.

The Pueblo houses are of uniform architecture, built of stone or adobes in terraces one upon another, the roof of one house being the yard of the next. Ladders were used both for exterior and interior climbing. Entrance was effected through a hole in the roof, through which also the smoke escaped. Doors, chimneys, and the dome-shaped ovens which seem so characteristic now were all introduced by the Spaniards. The women built the houses and later the churches as well.

The Pueblo people have always been weavers and potters, and it is believed that the "Navajo blanket" was introduced to the Navajos by Pueblo women. They raised cotton prior to the conquest, and the Spaniards introduced sheep. The Spaniards imposed an annual tax on the Indians of a yard of cotton cloth and a bushel of corn from each house.

In general the Spaniards were received with hospitality on their arrival in 1540, but the lightness with which Coronado viewed his promises to the Indians caused serious hostility. Not until Juan de Oñate (ohn-yah′tay) arrived in 1598 were the Pueblo tribes favorably influenced toward civilization. Oñate divided the country into districts, to each of which a priest was assigned. Missionary work flourished during the seventeenth century until the successful revolt of the Indians against the civil authorities in 1680. Then for 12 years the Pueblo people were free from Spanish dominion, but as during this time they were also deprived of Spanish protection, they suffered from the attacks of their ancient enemies, especially the Navajos and the Apaches. They were reconquered in 1692 by De Vargas, probably the greatest of the Spanish governors, and since then the Pueblo Indians have been at peace with the white men, both Spaniard and American. They still live in pueblos on their own land, most of which was covered by Spanish grants and is now in Government reservations. Their population has remained for several centuries at about 8,000.

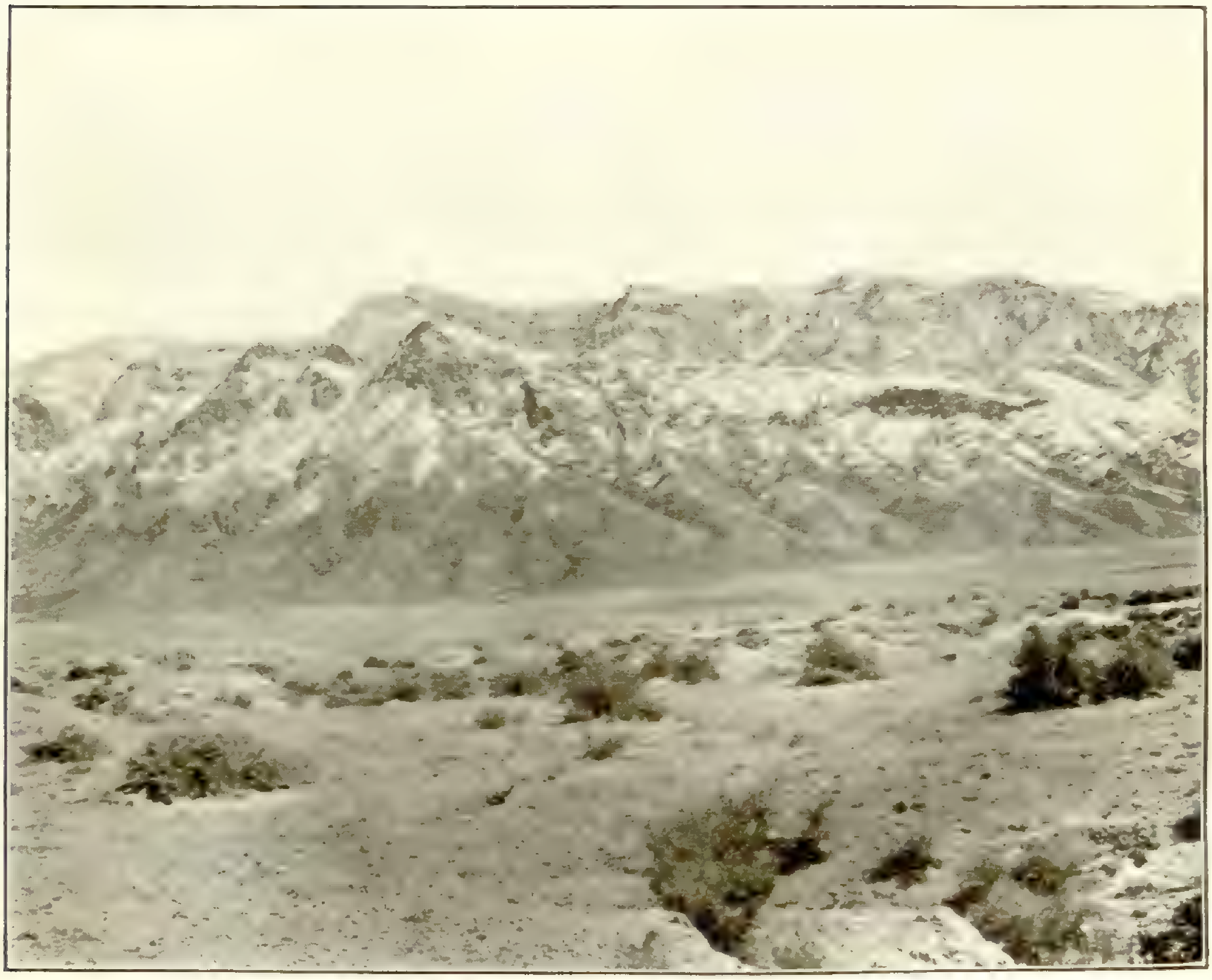
The ruins of one of the most famous of these historic pueblos is Pecos, the one above referred to, which lies 3 miles northwest of Rowe. In Coronado's time Pecos was a well-established city, known as Cicuye, much admired by the Spaniards. At that time it had two communal structures four stories high, with over 500 rooms on the ground floor, as well as other buildings, and a population estimated between 10,000 and 20,000. In 1617 the Indians erected an elaborate church, with four high towers, and a convent, under the encouragement of the missionaries, who established schools of reading, writing, and music. These Indians belonged to the Jémez (hay′mace) tribe, though their isolation led to their being considered a separate nation.

A. RUINS OF OLD PECOS CHURCH, NORTHWEST OF ROWE, N. MEX.

The ruins of a very large pueblo cover a hill near the church.

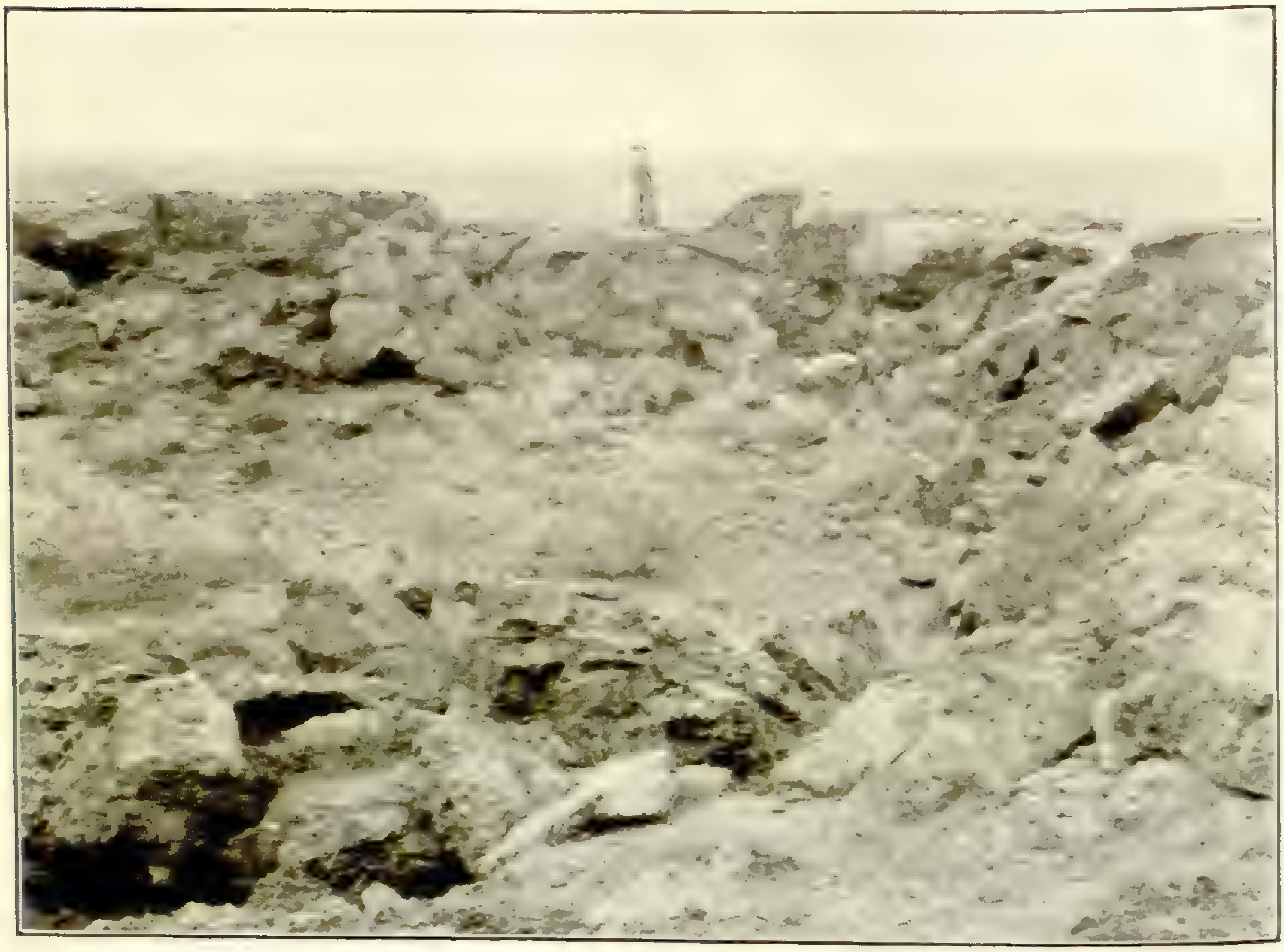
B. SANTO DOMINGO, N. MEX.

An Indian pueblo on the Rio Grande at the mouth of Galisteo Creek. Rio Grande in the distance.



A. WEST FRONT OF SANDIA MOUNTAINS NEAR BERNALILLO, N. MEX.

Granite and schist capped by sandstone and thick beds of limestone (Magdalena group). Plain of Santa Fe marl in foreground.



B. CRATER OF EXTINCT GEYSER THREE MILES WEST OF SUWANEE, N. MEX.

View northward; railway in distance. The material is silica deposited by hot water, which has built up a low cone around the crater.

The decline of this stronghold began with its revolts against the Spaniards. Then followed sanguinary raids of hostile Indians, one band of Comanches killing nearly every man of the tribe. Epidemics also devastated their ranks, so that finally only 17 survivors remained. They were removed to the parent village, Jemez. When Maj. Emory passed through this region in 1848 he found that the place had been abandoned only recently and learned that the devotional fire had been kept burning in the estufa (a sacred ceremonial chamber found in all the pueblos) until within a very few years. Now only the low mounds of ruins remain, except for the church, of which the heavy walls falling into ruins are still a landmark (see Pl. XII, *A*), as in the days of the Santa Fe Trail. These ruins have recently been acquired by the Historical Society of New Mexico, which has made provision for their preservation. Half a mile away was the favorite eating station on the entire trail, where notably substantial meals were served, including delicious trout caught in the stream near by. In this part of his journey the traveler passes picturesque canyons, cliffs, and mesas of varicolored rocks, among which deep reds and browns are the prevailing tints.

Glorieta.

Elevation 7,417 feet.
Population 349.*
Kansas City 841 miles.

The train makes a long, steep climb to Glorieta Pass, just west of Glorieta siding, where the road reaches an altitude of 7,421 feet in a cut 30 feet deep through the summit.[1] This pass is at the divide between the waters of the Pecos and those of the Rio Grande. To the north are fine views of the high peaks of the Rocky Mountains. One of the higher pinnacles, known as Thompson Peak, 10,546 feet above the sea, is about 7 miles northwest of Glorieta and plainly in view, and other peaks, some of them 2,000 feet higher, may be seen farther north. The range which culminates in these peaks and whose axis is crossed at Glorieta is described as the Santa Fe Range by some authors and as the Glorieta Mountains by others, but the entire system of higher ridges constituting the southern extension of the Rocky Mountains is usually called the Sangre de

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[1] The rocks at Glorieta station and in the slopes east and west are the lower members of the great series of red beds, in part of Pennsylvanian age, which are extensively exposed all the way from milepost 775. The rocks in the cut are red shales, including many beds of red, brown, and gray sandstones. They contain numbers of the leafy twigs, branches, and cones of Walchia, an ancient type of cone-bearing trees nearest related to the Norfolk Island pine (Araucaria), now so common in conservatories. The fossil plants found in this cut show the age of the rocks to be Permian. The red beds, most of which were laid down in fresh water, extend some distance up the slopes of the ridge north of the cut, where they give place to underlying limestones (the Magdalena) rising on a steep dip toward the east. Not far beyond appear the granites and schists of the main Rocky Mountain range. These rocks have been brought up by arching and faulting, and they rise rapidly into prominent peaks that constitute the main ridge.

Cristo Range. It extends continuously northward through northern New Mexico into Colorado. After passing through Glorieta Pass the railroad turns southwestward and follows a series of canyons and valleys, the headwaters of a branch of Galisteo (gah-lis-tay′o) Creek, on a continuous down grade to the Rio Grande at Santo Domingo. In 40 miles the descent is 2,175 feet, of which the steeper part (963 feet) is between Glorieta and Lamy.

This portion of the journey takes the traveler over a historic battle ground, for here occurred a decisive clash between Union and Confederate forces in 1862. A preliminary skirmish ending in favor of the northern forces was followed by a battle that lasted nine hours and ended in a truce. The Confederates, who were from Texas, were superior in numbers and equipment, but their stores were burned in a brilliant flanking movement. They returned to Santa Fe and the northern forces to Fort Union. This is variously known as the battle of Glorieta, of Apache Canyon, and of Pigeon's ranch, which was near the scene of battle.

Beyond the big cut at Glorieta there are extensive exposures of the lower red beds for some distance, extending up to the great cap of hard sandstone that constitutes the mesa to the east. This is the western face of Glorieta Mesa, which at Glorieta Pass turns southward. In a cut about 2 miles beyond the summit some thin-bedded blue clays, included in the red beds, contain the remains of fresh-water shells and insects, and ferns of Permian age. A short distance below milepost 829 the sandstone that caps the mesa is brought down below the track by an abrupt bend of the beds, and at this place it is well exposed in cuts and canyon walls. Not far west it is cut off by a great fault.

Canyoncito.
Elevation 6,855 feet.
Population 433.*
Kansas City 846 miles.

On leaving the narrow pass in the canyon the train passes the little Mexican village of Canyoncito on the right. At this place the Santa Fe Trail, which the railway has followed thus far down the canyon, turns to the west to cross the hills to Santa Fe. Canyoncito was a well-known point on the trail in the old days, when its stores, saloons, and hotels were well patronized. Not all the caravans, however, used this route, many of them, especially in the earlier days, leaving the main trail near Cimarron and crossing the range to the Indian pueblo of Taos and thence to the city. Santa Fe, the capital of New Mexico, is 12 miles to the northwest, at the west foot of the mountain range which is crossed at Glorieta.

Below Canyoncito the railway follows Apache Canyon, in which there are extensive exposures of the lower red beds on both sides. Just beyond milepost 832 the train enters a narrow gorge in granite which has been brought up by a fault. This granite extends for nearly a mile to another fault that cuts it off on the west. The canyon in the granite is very narrow, deep, and winding and presents many picturesque features carved in hard rock. This is the only place at which the oldest rock of the Rocky Mountains is crossed by the railway, and its presence here is due to two faults, or breaks in the earth's crust, along which a narrow wedge of the granite has been uplifted in relation to the adjoining red beds. At the mouth of the granite canyon, just east of the track, are the remains of the Lamy church and convent, built by the Spanish missionaries several centuries ago. It is now in ruins, but the general character of the building is evident.

Lamy.
Elevation 6,460 feet.
Kansas City 850 miles.

Most trains stop at Lamy, some of them to connect with a branch that extends north to Santa Fe, 18 miles, and some for meals at the remarkably pretty little hotel named El Ortiz. Lamy takes its name from the first American archbishop of Santa Fe. At Lamy the valley of Galisteo Creek widens, and although on its east side there are high masses of the southern continuation of Glorieta Mesa, the region to the west and south is mostly a rolling plain. This is part of the broad basin of the Rio Grande, which is occupied by a widespread accumulation of sands, gravels, and loams of Tertiary age. This basin extends far westward to the foot of the mountains, which may be seen in the distance, and down the Rio Grande valley through all of central New Mexico. The eastern edge of the Tertiary deposits lying against the older rocks is exposed in the ridges a short distance north and west of Lamy.

Eighteen miles north of Lamy and easily accessible by trains on the branch line is the quaint and interesting town of Santa Fe, one of the oldest white settlements in the country. It was established in 1605 by Juan de Oñate as a seat of the Spanish Government. Many of the ancient buildings and churches still remain. In the excellent museum kept by the State Historical Society in the old palace there are many souvenirs of the early and late history of New Mexico. This history has been one of extraordinary interest, from the time when a mere handful of Spaniards made Santa Fe their headquarters in controlling thousands of hostile Indians to the later days of the American occupation, beginning in 1846. The first Territorial legislature of New Mexico (then including Arizona) met here June 1, 1851. The church of San Miguel, the oldest church in the United States, is in Santa Fe.

To the transcontinental traveler the town is of special interest as the terminus of the old Santa Fe Trail. Every summer the caravans found on their arrival that people had come to Santa Fe from all sides, even from places as far away as El Paso, to purchase their wares, and many stores were opened in Santa Fe expressly for the sale of their goods. The wagons of many of the traders had a capacity equal to that of a small canal boat. They carried a load of domestic cottons, silks, hardware, etc., which they were able to sell at 50 to 100 per cent profit. This high rate was necessary considering not only the long and perilous journey of transportation but also the import tax that was levied upon these merchantmen of the plains by the Mexican authorities—an exorbitant duty, sometimes as high as 100 per cent. This entry duty was succeeded by another duty on the money carried away, so the early traders frequently invested their gains in beaver skins, which passed through free and yet netted a good profit on sale in St. Louis.

At the ruins of San Cristobal (cris-toe′bahl), which is only about 7 miles south of Lamy and is easily reached by a good road through the Pankey ranch, there are sandstone cliffs marked with many well-preserved Indian pictographs. They are opposite the site of San Cristobal pueblo, which has recently been extensively excavated. The pictographs were apparently traced by a hard-pointed stone or arrowhead. Pictures were of great importance to the Indians, not only those on rocks but the markings on their own bodies. The body markings often acted as personal badges—of bravery, marriage, freedom, or slavery—and in the same way, it is believed, most of the rock pictures recorded the achievement of some individual.

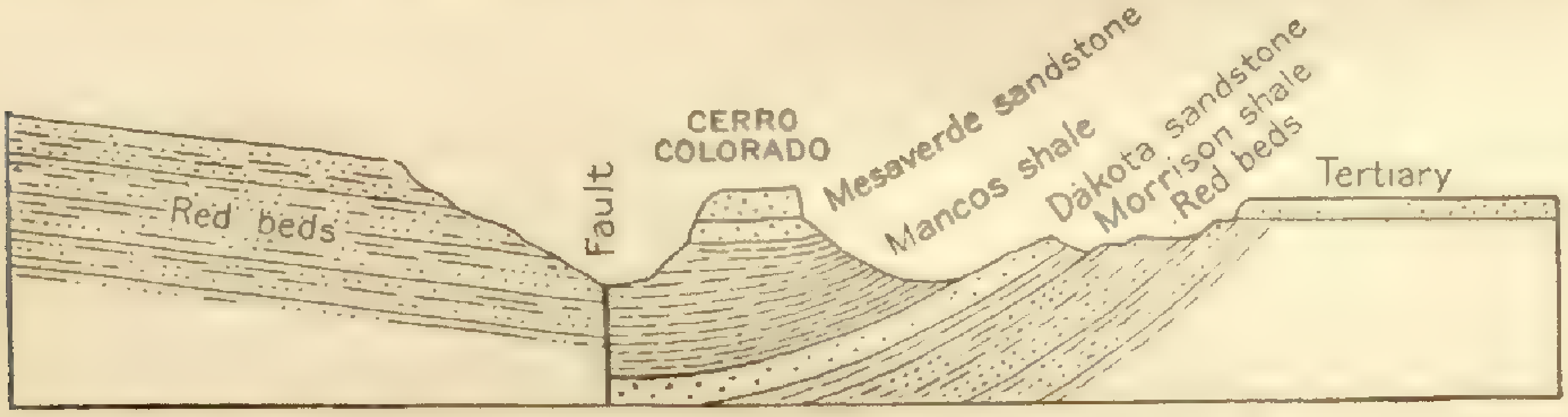

FIGURE 14.—Section across Galisteo Valley at Lamy, N. Mex.

Just west of Lamy station shales and limestones of Upper Cretaceous age (Mancos) are well exposed, dipping steeply eastward, and the Dakota sandstone and underlying Morrison shale crop out half a mile north of the station. On the east side of the flat east of the village these rocks are cut off by a prolongation of the fault which passes down Apache Canyon. East of this fault rise steep slopes of the red beds which underlie the high mesa extending southward from Glorieta Mesa. The relations of the rocks at Lamy are shown in figure 14.

The prominent butte just south of Lamy, known as Cerro Colorado, consists of Mesaverde sandstones overlying the Mancos shale. These sandstones dip southwestward and underlie the country on both sides of the railway for some distance. They are exposed extensively in railway cuts and form prominent ridges along the railway at intervals from Lamy to and beyond Kennedy.

Kennedy.
Elevation 6,006 feet.
Kansas City 859 miles.

A short distance north of Kennedy the Santa Fe line is crossed by the New Mexico Central Railroad, which extends from Santa Fe, 25 miles north of Kennedy, to Torrence, on the El Paso & Southwestern system, 90 miles south. Just north of Kennedy the railway crosses a vertical dike of basalt which extends east and west across the country for a long distance, cutting the sandstone. Its width averages about 30 feet, and, owing to the great resistance to erosion offered by the hard igneous rock, its course is marked by a distinct ridge from 30 to 100 feet high.

Two miles east of Kennedy is the Mexican village of Galisteo, which was an important settlement two centuries ago. A short distance north of it are numerous low red mounds with traces of walls marking the site of the Galisteo pueblo. In 1680, or at the time of the massacre, it had a population of about a thousand Tanos Indians under control of the Spaniards, who had erected a handsome church. Six miles east, up the creek, was another pueblo, San Cristobal, now marked by extensive ruins. Galisteo remained prominent until late in the eighteenth century, when the Tanos, greatly depleted by smallpox and the depredations of the Comanches, removed to the village of Santo Domingo, on the Rio Grande, a little farther west, where their descendants now live, preserving their language and many customs.

About 5 miles south of Kennedy is a prominent butte, known as Cerro Pelon (pay-lone′, Spanish for bald), which consists of a thick mass of igneous rock lying on sandstones.

Ortiz.
Elevation 5,820 feet.
Kansas City 862 miles.

A few rods beyond Ortiz, at milepost 847, is a quarry where a rock known as breccia is taken out in large blocks to be used in protecting the railway embankment at various places. This breccia consists of angular masses of volcanic rocks of various kinds mixed with more or less sand and cemented together into stone of considerable hardness. The cementing agent is lime or silica deposited by underground water passing through the deposit. This rock crops out in extensive cliffs on the north side of the track for some distance on both sides of Ortiz. It is a member of the Galisteo sandstone (of probable Tertiary age), which occupies a basin of considerable area extending northward under the sands and clays known as Santa Fe marl.

The name Ortiz, applied to various features in central New Mexico, belongs to a family which has been prominent in the history of the Southwest since the arrival of its founder with De Vargas's expedition of conquest after the pueblo revolt of 1680–1692.

A mile and a half beyond Ortiz siding the Ortiz Mountains are visible, 10 miles southwest of the railway. They consist of a thick body of igneous rock intruding the coal-bearing Mesaverde sandstone. Considerable gold ore has been found here and there along the slopes of these mountains and also in placer form in the wash of many of the draws leading out of them. The mining is done mainly by Mexicans; none of it is on a large scale, but it has been in progress for more than two centuries and at intervals still yields a small profit. Gold was taken from the Dolores mine in this district as early as 1830.

At milepost 849 the sandstones of later Cretaceous age rise from beneath the Tertiary beds and appear in ledges of considerable prominence just north of the railway, the ridge of breccia dropping back to the north. Halfway between mileposts 849 and 850, this sandstone contains numerous petrified logs,[1] some of them 50 to 60 feet long, exposed in a small area a short distance north of the railway. From this place westward the sandstones are conspicuous in prominent ledges, in which most of the beds dip steeply to the southeast. Buff is the prevailing color, but some of them are red.

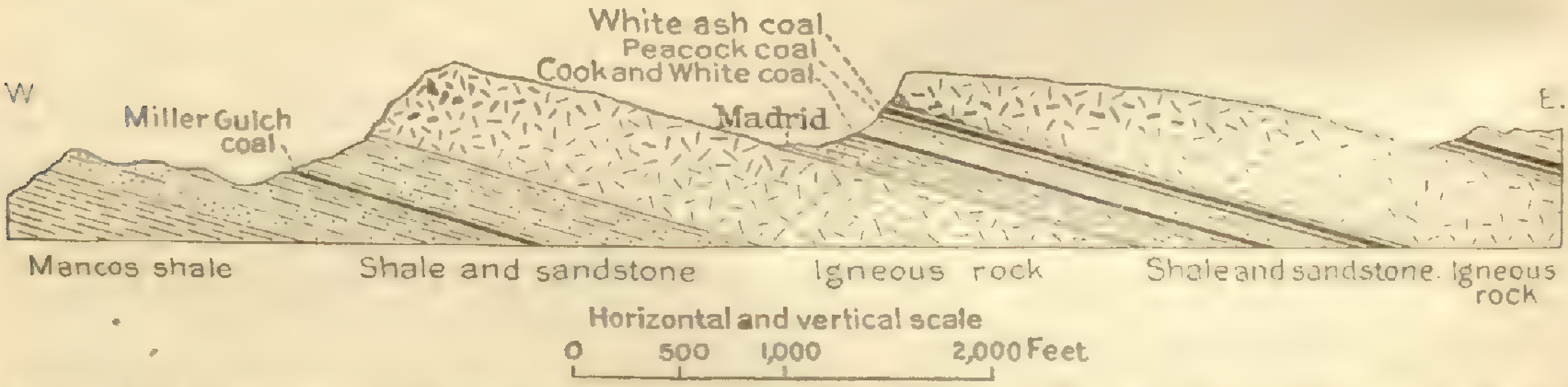

FIGURE 15.—Section through Madrid, 3 miles south of Los Cerrillos, N. Mex., showing relations of coal beds to the sheets of igneous rock.

Just north of the railway, halfway between mileposts 851 and 852, a large mass of igneous rock cuts across the beds of sandstone and shale. It was forced up in molten condition through cracks in the strata. A short distance farther west, where the igneous rock is quarried extensively, it is exposed cutting across vertical shales. This is in the eastern part of the village of Los Cerrillos.

Los Cerrillos.
Elevation 5,669 feet.
Population 674.*
Kansas City 868 miles.

Los Cerrillos (sair-reel'yos, locally sair-ree'yos; Spanish for little hills) is an old village sustained mostly by mining in the adjoining hills. At Madrid, a few miles south of it, are large coal mines whose product is taken by a branch railway to Waldo, the next station beyond Los Cerrillos. The total amount of coal so far mined is more than 2,500,000 tons, and the output in 1913 was approximately 68,000 tons. Coal was discovered here in 1835. Before the railway was constructed the output of the mines was small, but in 1882 the deposits here became a very important source of supply, and a large area has since been worked out. There are three principal beds of coal, ranging from 3 to 5 feet thick in greater part. The field is about 12 miles long and 3 to 8 miles wide. The coal occurs in sandstone and shale of the Mesaverde formation. An interesting feature of this place is that a considerable part of the coal has been converted into anthracite and some of it into coke by the heat of two extensive sheets of igneous rock which have been forced in a molten condition between the beds. A large amount of this anthracite is mined, most of it from a bed which in other parts of the area yields bituminous coal.

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[1] These appear to be the remains of a forest of Cretaceous age. The stems are largely chalcedonized, but the microstructure shows that they were conifers. (See also the description of the Petrified Forest, pp. 107-109.)

Four miles north of Los Cerrillos are the mines from which for many years our principal supply of turquoise was obtained. The mineral is found in small veins and other masses in an igneous rock (diorite porphyry), which cuts the Cretaceous shales and sandstones. It occurs very irregularly through the decomposed portions of the rock and also varies greatly in size, color, and suitability for use as a gem. It is believed that the turquoise has been deposited in cracks in the igneous rock by percolating waters which brought together, in solution, its constituents derived from the decomposing diorite porphyry. Besides the principal mine there are several small openings in which small pockets of turquoise have been found from time to time. The value of the product has risen to $500,000 in some years; in 1895 one stone obtained was valued at $6,000. The locality has been known to the Indians for many centuries and was the source of the material used by them, in large amount, for beads and jewelry. Some of them regard it as a specific against contagion. When Pedro de Tovar, one of Coronado's men, visited the Hopis in Arizona they presented him with specimens of turquoise which undoubtedly came from this place. Many of the early explorers visited the locality under the guidance of the Indians, for the place is referred to in the journals of all the expeditions which passed in this vicinity. On the slopes of Mount Chalchihuitl (tchal-tchi-wee′tl, the old Mexican name for turquoise), one of the minor peaks of the hills called Los Cerrillos,[1] the earliest observers discovered large pits that had been long abandoned, for the débris was overgrown with good-sized trees, and found numerous stone hammers. It was evident that the workings were of great antiquity.

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[1] The hills north of Los Cerrillos station are of similar origin to the Ortiz Mountains, on the south—that is, they consist of masses of igneous rock (diorite porphyry) that has been forced up in molten condition through the Cretaceous shales along irregular vents of various sizes. They constitute a group of six conical peaks occupying an area of about 12 square miles. The relations of one of these masses is well exposed a short distance east of the station, and other contact phenomena are visible at intervals in the next mile west. Nearly a mile west of Los Cerrillos a wall of the igneous rock rises 150 feet above the railway track and continues for nearly a quarter of a mile. At intervals westward past Waldo many large dikes of the igneous rock cut the shale, and most of them give rise to low but conspicuous ridges extending several miles across the country. Some of these dikes are plainly visible a short distance north of the railway.

The ruins of the old pueblo of San Marcos stand a short distance north of Los Cerrillos.

At Waldo the branch railway from Madrid joins the main line. West of Waldo the route crosses a thick body of Mancos shale, dipping mostly eastward. Near milepost 858, about 4 miles west of Waldo, the Dakota and associated sandstones and shales are brought up in regular succession from under the shales, and they present excellent exposures not far from the railway. The main mass of sandstone, which rises in a ridge of considerable prominence, is underlain by a thick series of sandstone and light-colored clays, believed to be the Morrison formation. These beds are underlain by a 60-foot bed of gypsum, which comes to the railroad in a high bluff at milepost 859 and continues in sight to the north for nearly a mile. This thick deposit of gypsum,[1] on account of its snow-white color and the large mass exposed, is one of the most conspicuous occurrences of the mineral in the Southwest.

Waldo.

Elevation 5,606 feet.
Kansas City 869 miles.

At Rosario siding the cliff of gypsum may be seen to bear off to the northeast, and the country for many miles west of that place is occupied by the sands, gravels, and loams of the formation known as the Santa Fe marl, which is of late Tertiary age. There are conspicuous exposures of this formation all along the slopes of the valley of Galisteo Creek, past Domingo station, to the Rio Grande. The beds lie nearly level and are mostly carved into badland forms. In some of the mesas in view far to the northeast these marls are overlain by some thick sheets of black lava (basalt), which were poured out over the plain before the valleys had been excavated as deep as they are at present.

By looking up the Rio Grande from the mouth of Galisteo Creek, which is 2 miles west of Domingo, the traveler may discern White Rock Canyon, through which the river flows for several miles and in which it is joined on the west by Pajarita and Frijole (free-ho′lay) creeks. In the deep canyons of these creeks are some of the most extensive and remarkable cliff dwellings in the West. The rock of the canyon walls is a volcanic tuff of very massive structure and only moderate hardness. This great body of tuff lies against the east flank of the Valle Grande (vahl′yay grahn′day) Mountains, which rise prominently 20 miles to the northwest. In the canyon walls this

Domingo.

Elevation 5,248 feet.
Kansas City 881 miles.

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[1] Gypsum consists of calcium sulphate with about 20 per cent of combined water. It is the source of plaster of Paris, which is used extensively in the arts and which is prepared by heating gypsum to a moderately high temperature to drive off the combined water and grinding the resulting mass to a fine powder.

tuff rises in high cliffs, in which thousands of excavations were cut by the aborigines. These places afforded particularly favorable conditions for dwellings, owing to their inaccessibility to the enemy and comparative ease of defense.

The cliff dwellings, of which there are many in New Mexico and Arizona, were occupied by Pueblo Indians and their ancestors, especially in time of danger from hostile tribes. Some of them were located near streams and fields and it is likely that they were occupied as dwelling places and for storage of grain and other property at times when no danger threatened. In the edge of the Jemez Plateau, which faces the Rio Grande a few miles north of Santo Domingo, there are thousands of caves that were thus used. The early history of the Pueblo people affords many examples of their willingness to abandon an old home, or even a pueblo, when it suited their interests to do so. This, in some measure, accounts for the great number of ruins in the Southwest, and thus it must not be imagined that cliff dwellings were deserted only because of the extermination of the tribe that had occupied them.

The Rio Grande, the east bank of which is followed by the railway from the mouth of Galisteo Creek to Albuquerque and beyond, is one of the longest streams in the United States, draining a wide area of the central Rocky Mountains in Colorado and northern New Mexico. Its valley was the natural route for all the exploring parties and the site of the settlements of many of their colonists. It was named by Hernando de Alvarado, of the Coronado expedition, Río de Nuestra Señora (River of Our Lady). The bottom lands that extend along the river at most places have been utilized for many centuries for agriculture and there are almost continuous settlements and ranches along both sides. As early as 1680 there were 19 ranches of Spaniards in the general Albuquerque region.

Many of the present ranches and villages are peopled by Mexicans, but there are also numerous settlements of Indians. One large Indian village is at Santo Domingo (see Pl. XII, *B*, p. 74), not far north of the railway, half a mile below the mouth of Galisteo Creek. This pueblo, known to be the third one built on this site, was established as Gipuyi 200 years ago. Because of its proximity to the Rio Grande it has suffered disastrously in three great floods. There are at Santo Domingo now about 800 Indians living in fairly comfortable adobe houses and cultivating an extensive area of adjoining fields, largely irrigated from the Rio Grande. These Indians have for a long time been the chief traders in the turquoise from Los Cerrillos. Together with those at San Felipe (fay-lee′pay), Cochiti (co-chee′tee), and several other pueblos, they are remnants of the eastern division of the Keresan tribe, of which the Acoma and Laguna Indians form the western division. They have a language very different from that of other Indians in New Mexico. On their feast day, which is about August 4 to 7, a great celebration occurs, with dances and other features. This is attended by a large number of people, who are made welcome.

Southwestward from Santo Domingo along the east bank of the Rio Grande there are extensive exposures of the Santa Fe marl in long slopes, partly of a badland character. In places on the west side this material constitutes the slopes of mesas of considerable height, which are capped by lava flows (basalt).

Opposite milepost 875, 2½ miles beyond Elota (ay-lo′ta) siding, there is another Indian pueblo, known as San Felipe. Although it is on the west bank of the river it is plainly visible from the trains, and many of its features may be seen in passing. A conspicuous building is the large church of curious architecture in the center of the settlement. As early as 1607 San Felipe had a church. The present town was built at the beginning of the eighteenth century. On top of the mesa a short distance north of San Felipe are ruins of a still older pueblo built for protection against the Spaniards. At a still earlier time the Indians had other places of residence, including Cubero (koo-bay′ro), all bearing the name Katishtya. These Indians, like those at Santo Domingo, are of Keresan stock. They now number about 500.

Behind San Felipe there is a moderately high mesa of Santa Fe marl capped by a sheet of black lava (basalt). The edge of this sheet shows the columnar structure characteristic of rocks of this kind. The lava came out of cracks some distance to the west and spread over a considerable area at a time when the bottom of the valley was about 150 feet higher than it is at present. There have been many of these eruptions at different places in the valley of the Rio Grande, as well as on some of the adjoining highlands, and volcanic activity appears to have continued until very recent time. The Pueblo Indians have traditions of "floods of fire," and it is stated that volcanic ash fell in seven of the twelve years following their revolt for independence from Spanish rule.

Algodones.

Elevation 5,089 feet.
Population 1,078.*
Kansas City 894 miles.

Algodones (ahl-go-doe′nace) is a Mexican village which is an important center and shipping point for ranches and the sheep industry. The valley of the Rio Grande in this vicinity contains many large fields of alfalfa and other crops irrigated by water supplied by canals from the river. The hills on both sides consist of the gray to pink Santa Fe marl, which extends along the valley in a belt of considerable width. On the west side of the river these beds are capped by a lava sheet forming a high mesa. This material is called marl because it is a fine light-colored silt, similar to the true marl deposited in ponds. Ridges rising out of the Santa Fe marl, at a point 6 miles northeast of Algodones, consist of the Dakota and associated sandstones and the red beds, while farther south the underlying rocks appear in a ridge of limestone (the Magdalena) which rises gradually to a high range known as the Sandia Mountains (sahn-dee′ah, Spanish for watermelon). This range is a very prominent feature that extends along the east side of the Rio Grande valley for 7 miles. Its higher summits rise somewhat above an altitude of 10,000 feet—that is, 5,000 feet above the river.

Ruiz.
Elevation 5,063 feet.
Kansas City 898 miles.

Ruiz (rwees) is a contraction of the name of the Franciscan friar Rodríguez, who organized a small expedition from Mexico in 1581. On an exploring trip through the pueblos, he and two other Franciscans remained after the departure of their soldiers. The three friars were murdered by the Indians, Rodríguez being the last of the three. He was killed in this neighborhood, and his body was thrown into the Rio Grande, which was then in flood.

On the west side of the river opposite Ruiz, a small body of black volcanic rock (basalt) is exposed, cutting across the marls and forming a small peak. Probably this represents a feeder for the lava flow on the mesa, which here trends off to the northwest.

Near Bernalillo the steep western front of the Sandia Mountains is plainly in view (Pl. XIII, *A*, p. 75). The greater part of the slope is granite and schist, but at the top there is a capping of several hundred feet of limestone, which also dips continuously down the more moderate eastern slope of the range. This limestone presents to the west a light-colored, almost unbroken cliff of considerable height, which is readily recognized above the darker, rugged, granite slopes. A cross section of the Sandia Mountains[1] is given in figure 16.

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[1] This range is the northernmost of a series of nearly similar ranges which stretch from north to south east of the Rio Grande, extending as far south as El Paso, where they abruptly end. The limestone capping the Sandia Mountains is of later Carboniferous age (Magdalena group), and in the valley east of the mountains it dips beneath a thick series of red beds (Pennsylvanian to Triassic), as shown in the section. It has long been supposed that the beds on the west front of these mountains are cut off by a great fault, or in other words that they are due to an uplifted block of the earth's crust broken off along its west side. There is, however, considerable evidence afforded by small exposures of limestone along the west foot of the mountains to show that they are due mainly to an upward arch of the strata, effected mostly by bending, but doubtless with minor local breaks. Most of the limestone and the overlying rocks that extend along the west foot of the mountains are covered by a thick sheet of the Santa Fe marl, which occupies a large part of the Rio Grande valley. These deposits crop out at many places in the slopes on both sides of the river. They are sands and fine loams, with some layers of reddish tint, all lying nearly horizontal. The broad basin or old valley which they occupy is excavated in soft shales of Cretaceous age.

Bernalillo.
Elevation 5,033 feet.
Population 1,000.*
Kansas City 902 miles.

Bernalillo (bare-nah-leel′yo, locally ber-nah-lee′yo; Spanish for little Bernard) was so named because it was settled by descendants of Bernal Díaz del Castillo, who was associated with Cortez in the conquest of Mexico. The population consists mainly of Mexicans, and the village is one of the oldest settlements in the valley. The fertility of the wide valley and the favorable conditions for irrigating by use of the water of the Rio Grande have been the principal factors in sustaining a large settlement at this place. De Vargas, the Spanish governor who restored Spanish domination after a lapse of 12 years, died here in 1704. There have been Indian villages on the same site and in the vicinity for centuries.

A short distance north of Bernalillo began the province of the Tigua group of Pueblo people, who became famous through the narratives of the early historians. They comprised three geographic divisions, of which the one living in the region extending from Bernalillo 35 miles south was the middle. The reported population in 1630 was 7,000, living in 15 or 16 pueblos. Their principal settlement, Puaray (pwa-rye′), called by the early explorers Tiguex, lies in ruins at the south end of the present village of Bernalillo. It was probably here that Coronado spent his first winter and here that he conducted a 50-day siege during the revolt of the Tigua villages against him. His success led to the first plundering of the town by the Spaniards; the last occurred at the time of the general revolt of the Pueblos against Spanish rule in 1680 and resulted in the final abandonment of the village by the Indians.

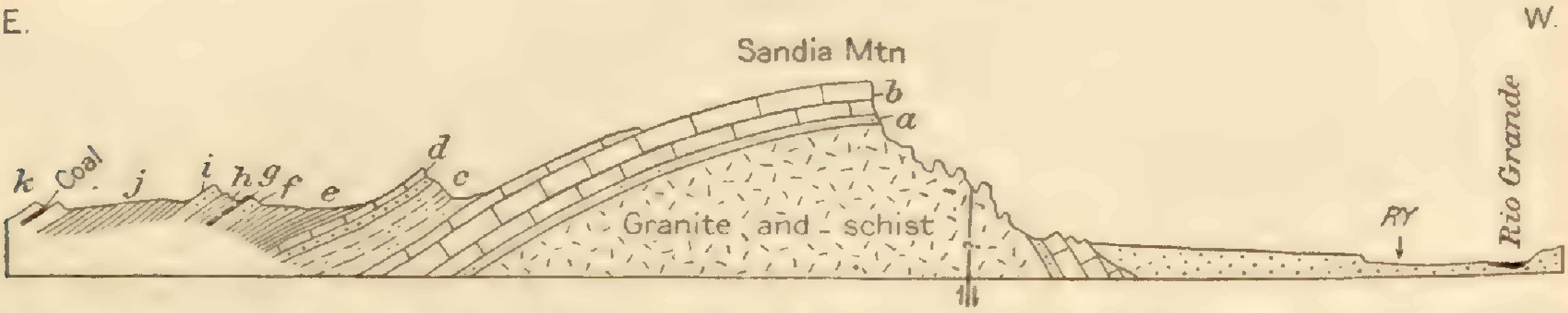

FIGURE 16.—Section through Sandia Mountains, near Bernalillo, N. Mex., looking south. *a*, Sandstone; *b*, Magdalena limestone; *c*, red sandstone; *d*, gray sandstone and limestone; *e*, red shale; *f*, massive red sandstone (Wingate); *g*, gypsum and limestone; *h*, Morrison shale; *i*, Dakota sandstone; *j*, Mancos shale; *k*, Mesaverde coal measures.

From Bernalillo to Albuquerque, a distance of 16 miles, the railway continues along the east side of the Rio Grande, but in some places it is separated from the stream by wide alluvial flats, which at Albuquerque are more than a mile across. The Tigua pueblo of Sandia is on the east side of the Rio Grande about 12 miles north of Albuquerque. It was visited by Coronado and had many vicissitudes of abandonment and burning, but was reestablished by the missionaries.

Alameda.
Elevation 4,980 feet.
Population 554.*
Kansas City 910 miles.

Ten miles from Albuquerque is the ruined pueblo of Alameda (ah-lah-may′da, Spanish for row of cottonwoods). This was a Tigua village which was built upon the banks of the Rio Grande, but owing to a change in the course of that variable stream, it lies now a mile from the river's edge. Here Cárdenas had 200 Indians burned at the stake, a crime for which he was thrown into prison when he returned to Spain. Like its companion villages of Puaray (at Bernalillo) and Sandia, Alameda was burned by the Spaniards at the time of the general uprising in 1680.

To the east there are fine views of the west front of the Sandia Mountains. (See Pl. XIII, *A*, p. 75.) Near Albuquerque it may be seen that this range is terminated on the south by a deep gap, south of which rises another range, of similar structure, known as the Manzano Mountains.

Albuquerque.
Elevation 4,954 feet.
Population 11,020.
Kansas City 918 miles.

The portion of Albuquerque (ahl-boo-care′kay) known as "old town" extends along the river bank a mile to the west; the part near the railway is much younger. The city was founded in 1701 by Gov. Pedro Rodríguez y Cubero, who established 30 families there and applied to it the name of the Duke of Alburquerque, who had been viceroy of New Spain. The duke, who never came to America, ordered the name changed to San Felipe de Alburquerque as a compliment to the reigning king. In the course of years the name has been reduced to one word and a slight change has been made in the spelling. Albuquerque was an important center in the Spanish and Mexican occupation, and Gen. Phil. Sheridan made it his headquarters until 1870. It is now the largest city in New Mexico and is an important commercial and industrial center. It is a railway division point, with large machine shops and a plant for creosoting railway ties. All the trains stop for half an hour or longer, close to the large Alvarado Hotel, named for Hernando de Alvarado, who accompanied Coronado on his journey of discovery and conquest. In one part of this beautiful building is an interesting salesroom of Indian goods, which is a museum of Indian arts. The entire building is in the mission style. Indians from Isleta frequent the corridor of this building, offering pottery and other products of their handicraft at low prices.

In the eastern part of the city, about a mile from the station, are the State University buildings, of Pueblo Indian style, and in the old town to the west still stands the mission church of San Felipe de Neri, built in 1735.

From Albuquerque an important branch of the Santa Fe continues south down the Rio Grande valley to El Paso, and from this branch another diverges at Rincon to Deming, Silver City, and Lake Valley.

The railway was built through to Albuquerque in 1880 and the line to Deming was opened in the spring of 1881. For some time before the building of the Atlantic & Pacific Railroad, now the western part of the Santa Fe system, this line by way of Deming and thence over the Southern Pacific was the principal outlet to the Pacific coast.

There are but few mines in the vicinity of Albuquerque, although some small ones are worked for gold and other metals in the mountains to the east. Much of the product of the many ranches is brought to the city, and the wool from a wide area is received there, most of it passing through a scouring plant that handles 7,000,000 pounds a year. The gross annual trade in sheep in the vicinity amounts to about $10,000,000.

On leaving Albuquerque the train goes nearly due south, passing Abajo (see sheet 14, p. 98) and continuing along the east side of the Rio Grande valley for about 10 miles. To the west is a mesa of moderate height, capped by a thin sheet of lava which appears to have flowed from several small cones rising above its surface some distance back on the mesa and in plain view from the trains. This lava lies on the Santa Fe marl, which occupies the Rio Grande valley through the greater part of central New Mexico. The railway crosses the Rio Grande[1] 10½ miles from Albuquerque and follows the west bank 2 miles to Isleta.

Abajo.

Elevation 4,945 feet.
Kansas City 920 miles.

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[1] This stream is one of variable volume; during the dry season it dwindles to a few small shallow channels and even becomes dry at the surface in many places, but early in the summer and sometimes at intervals later it carries great floods, which usually overflow most of the adjoining lower lands. For a large part of the year the flow near Albuquerque averages about 1,500 cubic feet a second, but in some years the average flow is less than 500 cubic feet a second. At times of flood the volume of water is 10,000 to 20,000 cubic feet a second or even more. It is estimated that the average total yearly flow is sufficient to cover 400,000 acres (625 square miles) to a depth of 3 feet, which is the amount required for most irrigation in this region.

The great differences in flow are due to the variations in the amount of rainfall and in some degree to the nature of the country drained by the river. The greater part of the surface in the Rio Grande basin has a very scanty cover of vegetation, so that but little of the rainfall is absorbed by the soil or passes underground; therefore it runs off rapidly into draws and creeks and soon reaches the river. Most of the rainstorms, though relatively short, are violent, and when the storm area is large a vast amount of water is carried into the river.

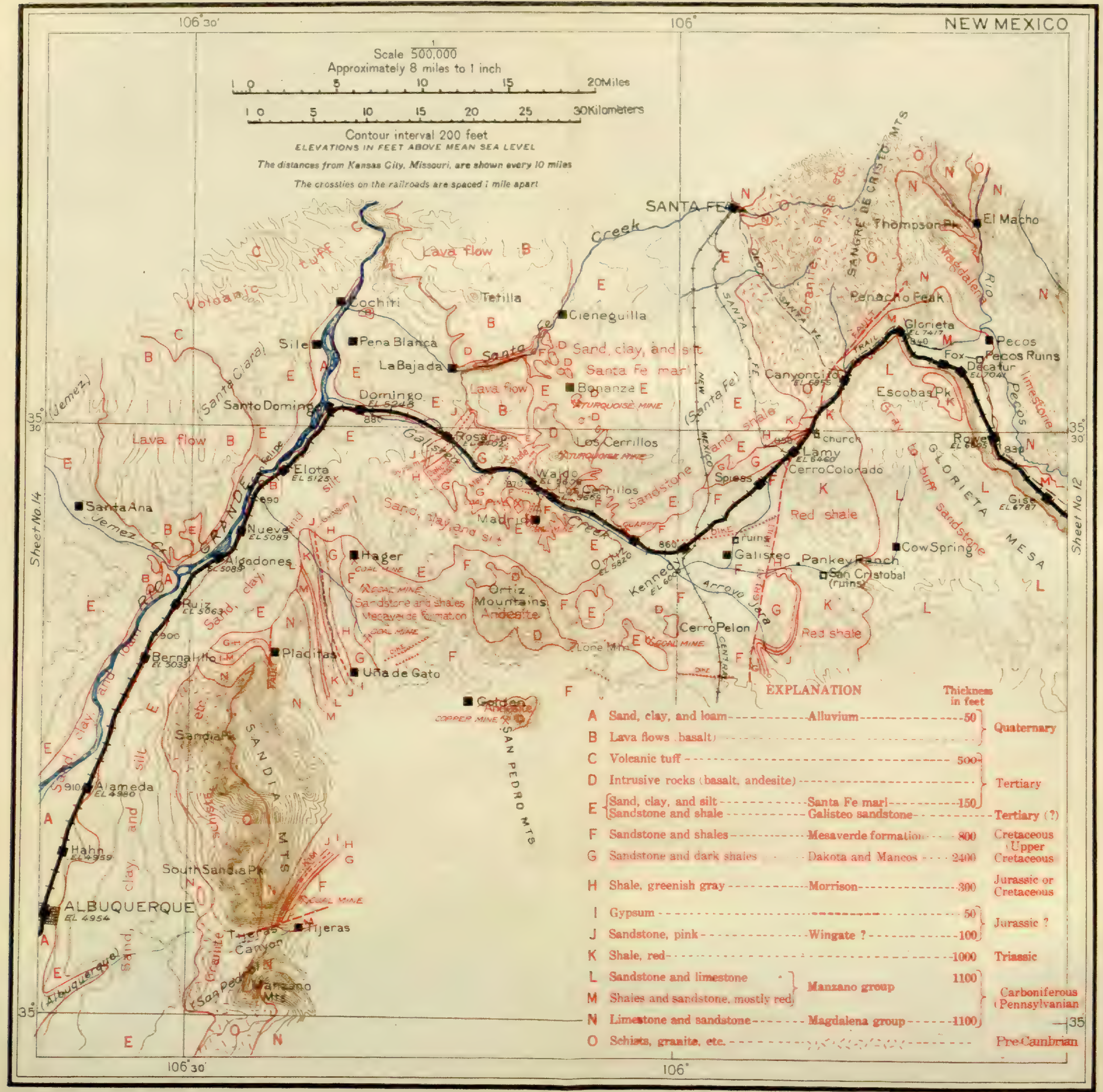
As a rule, most of the water of river floods is lost, for the water used for irrigation is taken out at times when rivers are at the ordinary stage of flow, and no provision is made for storing the floods. In the Rio Grande valley, however, this condition is soon to be changed, for the United States Reclamation Service is building a storage dam near Elephant Butte, about 140 miles below Albuquerque. The dam will be 1,200 feet long, 300 feet high, and 215 feet wide at the base and will contain 600,000 cubic yards of masonry. It will create a lake 41 miles long, extending nearly to San Marcial with an average width of 1¾ miles and a capacity of 862,000,000,000 gallons, or more than

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
SANTA FE ROUTE
From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atchison, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist   R. B. Marshall, Chief Geographer
1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.


NEW MEXICO
106° 30'
106°
35° 30'
35°
Scale $\frac{1}{500,000}$
Approximately 8 miles to 1 inch
1 0 5 10 15 20 Miles
1 0 5 10 15 20 25 30 Kilometers
Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart
Sheet No. 14
Sheet No. 12
SANTA FE
Santa Fe Creek
Cochiti
Sile
Pena Blanca
La Bajada
Tetilla
Cieneguilla
Bonanza
Turquoise Mine
Santo Domingo
Domingo
Elota
Nueve
Algodones
Bernalillo
Alameda
Hahn
ALBUQUERQUE
Santa Ana
Jemez
Rio Grande
Hager
Placitas
Uña de Gato
Golden
Copper Mine
Rosario
Los Cerrillos
Waldo
Cerrillos
Madrid
Ortiz Mountains
Andesite
Galisteo Creek
Kennedy
Ortiz
Lone Mtn
Cerro Pelon
Coal Mine
Galisteo
Spiess
Lamy
Cerro Colorado
Canyoncito
Glorieta
Decatur
Fox
Pecos
Pecos Ruins
Rowe
Gise
Escobas Pk
Cow Spring
Pankey Ranch
San Cristobal (ruins)
Thompson Pk
El Macho
Penacho Peak
Sangre de Cristo Mts
Glorieta Mesa
Sandia Pk
South Sandia Pk
Sandia Mts
San Pedro Mts
Tijeras
Tijeras Canyon
Manzano Mts
Volcanic tuff
Lava flow
Sand, clay, and silt
Santa Fe marl
Sandstone and shales, Mesaverde formation
Red shale
Granite
Limestone
New Mexico Central
EXPLANATION
Thickness in feet
A Sand, clay, and loam - Alluvium - 50
B Lava flows (basalt)
Quaternary
C Volcanic tuff - 500
D Intrusive rocks (basalt, andesite)
E Sand, clay, and silt - Santa Fe marl - 150
Tertiary
E Sandstone and shale - Galisteo sandstone - Tertiary (?)
F Sandstone and shales - Mesaverde formation - 800
G Sandstone and dark shales - Dakota and Mancos - 2400
Cretaceous (Upper Cretaceous)
H Shale, greenish gray - Morrison - 300 - Jurassic or Cretaceous
I Gypsum - 50
J Sandstone, pink - Wingate ? - 100
Jurassic ?
K Shale, red - 1000 - Triassic
L Sandstone and limestone - 1100
M Shales and sandstone, mostly red
Manzano group
N Limestone and sandstone - Magdalena group - 1100
Carboniferous (Pennsylvanian)
O Schists, granite, etc. - Pre-Cambrian
Engraved and printed by the U.S. Geological Survey

Isleta consists mainly of an Indian pueblo built on the bank of the river a short distance east of the railway. This pueblo may be seen best from points a short distance north of Isleta station.[1] Isleta, named thus by the Spaniards on account of its location on an islet in the Rio Grande, was discovered by Coronado in 1540. It was a Tiguex village but has had accessions of Indians from other pueblos. At the time of the rebellion of 1680 it revolted, together with the other Tiguex villages of the Bernalillo and Santa Fe region. The Spanish governor stormed it and captured over 500 natives. These were sent as captives to El Paso and the rest of the tribe fled for refuge to the Hopi pueblos in Arizona. Early in the eighteenth century the pueblo was resettled under the name San Agustín de la Isleta.

Isleta.
Elevation 4,896 feet.
Population 1,085.*
Kansas City 930 miles.

From Isleta, on the Rio Grande, which flows into the Gulf of Mexico, the railway begins its long journey across the interesting plateau country, which, with its bordering areas, extends almost to Colorado River, which flows into the Pacific. This vast area of high, nearly level country lies between the rugged and generally higher ranges of the Rocky Mountains to the north and the alternating short ranges and deserts of the lower lying north end of the Mexican plateau country to the south.

This is a land of interesting landscapes, rocks, and people. In places the plains and cliffs are vividly colored by natural pigments of red and vermilion. The rocks of the plateau are surmounted by two large volcanic piles, which stand far above the general level of the plain and which were master volcanoes in but comparatively recent time—Mount Taylor on the east and the San Francisco Mountains on the west. From the immensely thick, almost horizontal sedimentary strata that compose most of the mass of this plateau layer after layer has been eroded away over wide areas, leaving remnants of harder strata which make picturesque cliffs and valleys and exposing fossil forests that were long ago buried in the sediments of which these strata are made. Erosion has also carved many canyons, notably the majestic Grand Canyon of the Colorado.

2,500,000 acre-feet. This basin will hold the floods of the Rio Grande and conserve the water for use when needed for irrigation all along the river in southern New Mexico and Mexico. Of course it will not prevent floods in the Albuquerque region and higher in the valley, but it will save that water for use in a region where it can be utilized advantageously for irrigation. In January, 1915, the Elephant Butte dam was said to be about two-thirds built, and a large volume of water will be held in 1915.

[1] This station is at milepost 915. The numbering of the mileposts from Atchison continues south from Isleta along the El Paso branch line. Mileposts on the main line west of Isleta indicate distance from Albuquerque.

Here and there in the rocky cliffs and canyons are the present and former communal homes of aboriginal peoples, whose arts and religious ceremonials partly lift the veil of the past and reveal glimpses of earlier stages of human culture. These vast expanses were long ago the abode of aboriginal tribes; later they were explored and dominated by the mounted Spanish conquistadores; and finally they have been made accessible to all by the comfortable railway of to-day. The plateau country and its approaches, in all their aspects—geologic, ethnologic, and historical—form a region which will hold the attention of all passers-by in whom there exists a spark of appreciation of striking natural phenomena and significant human events.

Sandia.
Elevation 5,286 feet.
Kansas City 941 miles.

A short distance beyond Isleta the main line of the Santa Fe begins its climb out of the valley of the Rio Grande, ascending by a rather steep grade to the mesa which lies west of the river flat. The crest of this mesa is reached at Sandia siding.[1] In the cuts on this ascent there are many exposures of sands and loams (Santa Fe marl) which are capped by sheets of lava and volcanic cones on both sides of the track. The railway reaches the edge of the lava sheet a short distance beyond milepost 16 and passes over it for 2 miles or more. There is a group of volcanic cones 2 miles west and another group to the northwest of milepost 21. From these cones small flows of lava spread over areas of moderate extent at a time not very remote geologically, when the river valley was about 200 feet less deep than at present.

From the top of the mesa just beyond Sandia siding there are extensive views in every direction. About 15 miles to the east may be seen the bold western front of the Manzano Range, the high ridge which constitutes the southern extension of the Sandia Mountains and which is of similar structure. Far to the south is a prominent peak known as the Sierra Ladrones (lah-dro′nace, Spanish for thieves), consisting of a large but isolated mass of pre-Cambrian granite overlain by limestone of the Magdalena group. To the west is a wide region of high plateaus,[2] out of which rises a very prominent peak, known as

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[1] This place should not be confounded with the ancient pueblo of Sandia, which lies 12 miles north of Albuquerque.

[2] The region west of the Rio Grande, well known to geologists as "the plateau country," is a province which differs in its geography and geologic structure from most of the country to the east. The width of this plateau province is about 450 miles, its western margin being far to the west in Arizona. The predominant type of structure is widespread tabular surfaces or plateaus consisting of great sheets of the various sedimentary rocks lying nearly horizontal or presenting very wide dip slopes. Most of these plateaus extend across the country in huge steps with steep fronts and relatively level or smooth tops. The harder formations constitute the surface of the plateaus; the softer beds crop out in the slopes. There are many mesas or portions of these plateaus cut apart from the main area by erosion.

The rocks are sandstones, limestones, and shales of Cambrian to earlier Tertiary

Mount Taylor, 11,389 feet high. It will be seen that the mesa or high plain of Santa Fe marl extends far to the north and south, partly filling a broad basin between the mountains. Originally its surface was a continuous plain, but the Rio Grande has cut a wide valley for itself 200 feet or more deep through the center of the plain, and now the river flows along the bottom of this valley, with a mesa or plateau of the "marls" forming cliffs or slopes on each side.

After crossing the low divide on the plateau beyond Sandia siding the train descends by a tortuous route to the valley of the Rio Puerco (pwair′co, Spanish for dirty). On the way it passes through many cuts in the Santa Fe marl that exhibit the characteristics of the deposits, which are mostly sands and loams, in some places consolidated into loose sandstones.

The Rio Puerco is a long stream draining the mesa country to the northwest and emptying into the Rio Grande some distance southeast of the crossing. Its valley is excavated mostly in soft beds of the Santa Fe marl and underlying shales (late Cretaceous). To the west is the Mesa Lucera (loo-say′ra), a plateau capped by a thick sheet of lava (basalt) lying on sandstones and shales. These strata dip steeply eastward in a low line of foothills extending along the east side of the mesa, but they are nearly level under the lava cap.

A short distance south of Rio Puerco station there are several small knobs of volcanic rock rising above the wide valley bottom.

Rio Puerco.
Elevation 5,049 feet.
Kansas City 953 miles.

West of Rio Puerco siding the old main line is paralleled for a few miles by a new track diverging to the left for the westbound traffic and rejoining the old line a short distance beyond South Garcia (gar-see′ah) siding. From Rio Puerco to the Continental Divide, a distance of nearly 100 miles, the railroad ascends the valley of the San Jose (ho-say′), which empties into the Rio Puerco at Rio Puerco station.

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age, capped on some of the plateaus and mesas by thick sheets of lava. At many places high cones or necks of older volcanic rocks rise above the platforms, and widely scattered cinder cones mark the orifices of later eruptions. The province is markedly different in physiographic and structural characters from the Rocky Mountain country on the east and the region of deserts and long rugged ridges on the west.

This section of the country is one of great interest to the student of geology, for most of its relations are clearly exhibited, and therefore it presents more striking illustrations of geologic features than the adjoining provinces. It extends far to the north of the railway in New Mexico, Arizona, and Utah, and for some distance to the south through central New Mexico. It is a region in which the beds constituting the earth's crust have been uplifted or depressed in broad waves and in places dislocated by faults or breaks, along which great blocks have moved bodily up or down on one side in relation to those on the other side. These peculiar structural conditions, due to a special kind of stresses in the earth's crust, are here localized in a zone of relatively great extent, surrounded by regions in which there is much more intense tilting and breaking of the strata by folds and faults.

Near milepost 39 is the termination of a narrow flow of lava, which appears to extend continuously from a source far up the valley. It widens in some places and narrows in others, and at intervals is covered in whole or in part by the alluvium or wash laid down by the stream.

Suwanee.
Elevation 5,455 feet.
Kansas City 968 miles.

Suwanee station is on this lava sheet. A short distance to the southeast is a small mesa in which an older lava sheet caps buff sandstone (Dakota), shales (Morrison?), and underlying gray and red massive sandstones (Zuni). Farther south is the precipitous edge of the lava sheet capping the high north end of the Mesa Lucera.[1]

A fault of considerable magnitude is crossed a short distance west of Suwanee station and extends far north along the eastern margin of the high plateau known as Mesa Gigante (he-gahn'tay, Spanish for gigantic). This fault is a vertical break in the earth's crust along which the region to the west has been uplifted several hundred feet, bringing into view a thick mass of red beds. The relations are as shown in figure 17.

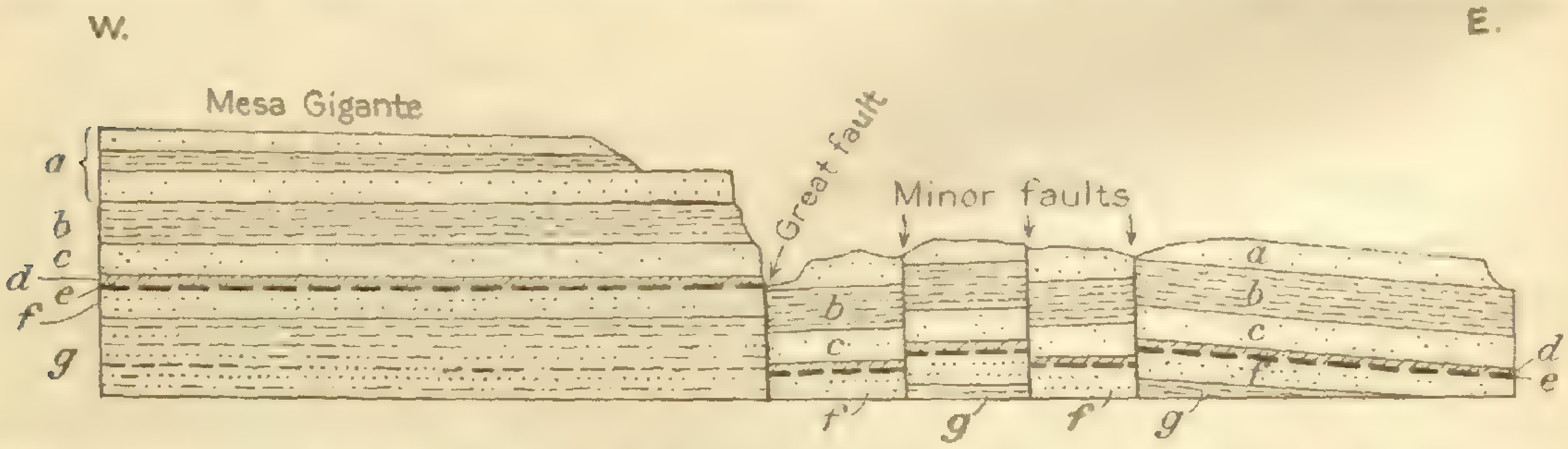

FIGURE 17.—Section north of Suwanee, N. Mex., looking north, showing relations of faults. *a*, Dakota and overlying sandstones and shales; *b*, shale probably equivalent to the Morrison formation; *c*, buff massive sandstone; *d*, red sandstone; *e*, gypsum on thin-bedded limestone; *f*, massive pink sandstone (Wingate); *g*, red shales and sandstones.

Where crossed by the railway this fault is covered by lava because the lava occupies a valley that was excavated long after the earth movement had taken place. North of the railway and west of the fault rises the Mesa Gigante, which is capped by massive gray to buff sandstones (Dakota and overlying Cretaceous). Below the sandstone cliffs are banks of shale or clay, in greater part of pale-greenish tint (probably equivalent to the Morrison formation), descending to long slopes and extensive cliffs of red sandstones and shales. These red cliffs are very conspicuous, notably from points near Armijo (ar-me'ho) siding and for some distance westward.

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[1] A mile north of Suwanee on the north side of the valley is a long ridge of moderate height capped by buff sandstones (Dakota) surmounting slopes of light greenish-gray clays probably equivalent to the Morrison formation. These clays are in turn underlain by a thick layer of massive buff sandstone, and in the bottom of the valley, not in view from the train, the top of a 50-foot bed of the underlying gypsum is exposed in a small area. Small faults which extend northward into the ridge at this place cut off the gypsum on the east and west.

Three miles west of Suwanee there is an extinct hot spring or geyser cone not far south of the tracks. (See Pl. XIII, *B*, p. 75.) It contains a shallow crater 30 feet in diameter with walls of a hot-spring deposit, which also constitutes the low cone in which it is situated. The form of the bowl and cone indicates that at a time not very remote there was at this place a hot spring, or possibly a geyser similar to those now active in the Yellowstone Park. South of Armijo siding a large valley from the south enters that of the San Jose. About 10 miles up this valley is a large recent volcanic cone, Cerro Verde (vair′day), and its lava flow appears to extend down to the San Jose Valley.

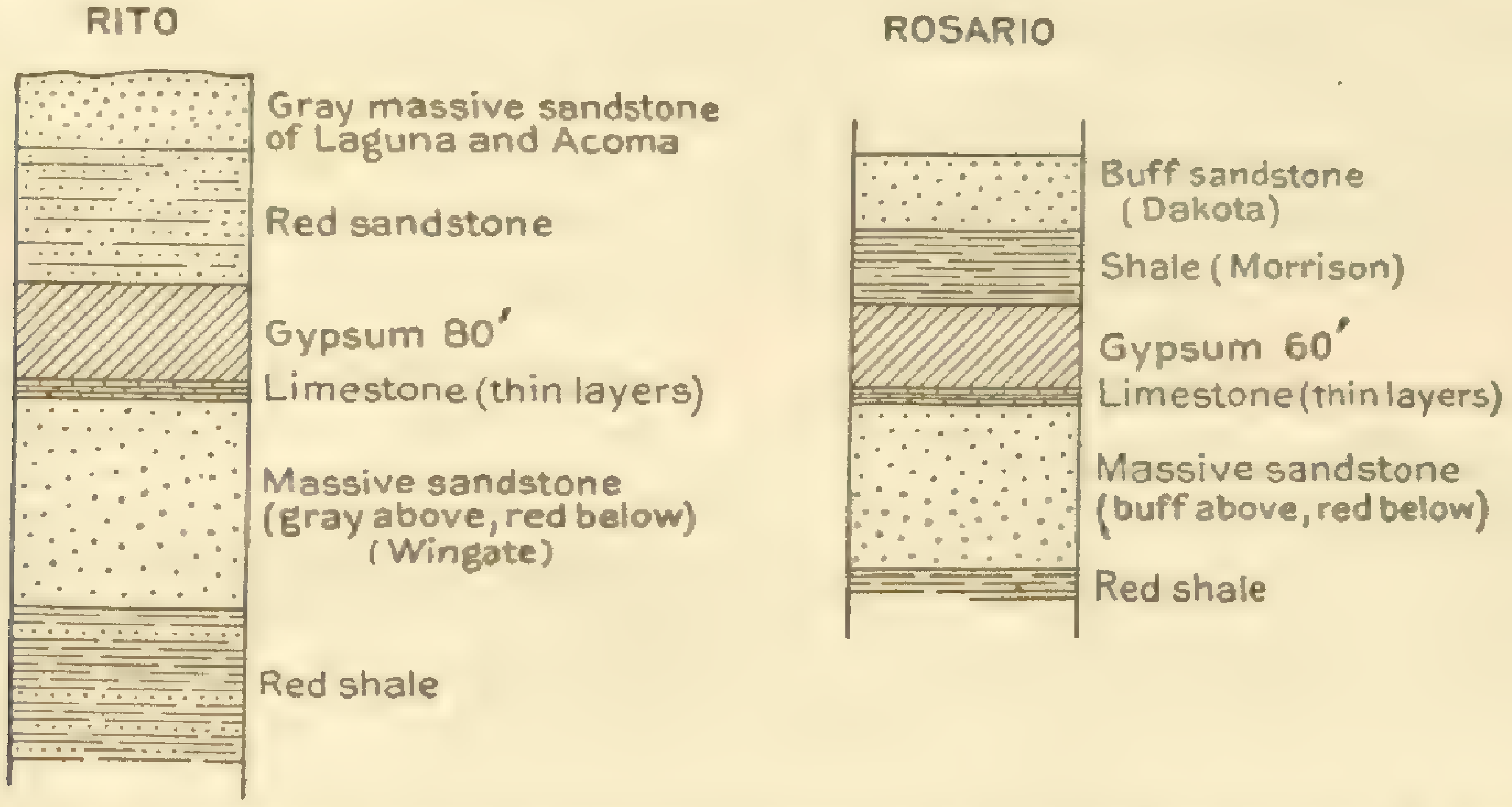

FIGURE 18.—Sections showing relations of gypsum bed at Rito and near Rosario, N. Mex.

Rito.

Elevation 5,664 feet.
Kansas City 981 miles.

At Rito (ree′to) the railway passes a small pueblo (El Rito) of Laguna Indians, built on a low lava-capped plateau a short distance south of the railway. There are now only a few Indians at this place, as those living higher up the valley cut off the water during the irrigating season. These Indians subsist by raising sheep and goats and cultivating small crops.

South of Rito there is a high mesa of red and buff sandstone (Zuni) extending far to the south. To the north is a high cliff capped by bright-red sandstones, at the base of which is the outcrop of a great deposit of pure-white gypsum, 50 feet or more thick. As shown in Plate XIV, *B* (p. 96), it extends along the north side of the track for some distance. It is one of the most prominent exposures of gypsum known, rivaling the one east of Rosario station (see p. 82) and apparently of the same age. Figure 18 is introduced to show the succession of rocks in which the gypsum occurs at both places. This bed of gypsum crops out at several points in the region between Rosario and Rito with the same relations to adjoining rocks, so that there is no doubt as to its continuity. It is the same deposit which is exposed north of Suwanee, as shown in figure 17. It has been removed by erosion over wide areas where the rocks are uplifted, but, on the other hand, it underlies a district of great extent in which it has not been sufficiently uplifted to be subjected to erosion.[1]

West of Rito the San Jose Valley narrows considerably and the railway follows its very crooked course to Quirk siding. In this interval there are numerous exposures of the edge of the lava flow which ran down the San Jose Valley to and beyond Suwanee. Most of the lava is south of the railway in this vicinity; on the north side are bluffs of the buff Zuni sandstone above referred to. This sandstone is also exposed in deep railway cuts west of Quirk, where it is overlain by light-colored shales and clays that extend up to a thick succession of sandstones (Dakota and higher). In the high mesas a mile or two north of the railway these sandstones are capped by a sheet of older lava (basalt).

Laguna.

Elevation 5,797 feet.
Population 1,583.*
Kansas City 988 miles.

Laguna station is nearly a mile north of the Indian pueblo of Laguna, through which the railway passed prior to a recent change of course to diminish distance and grade. This pueblo is one of the most interesting and accessible along the Santa Fe Railway and is visited by many tourists, who find accommodations, if necessary, at the houses of some of the American residents of the small settlements adjoining the pueblo.

The Indians at this place are a branch of the Keresan tribe, to which the Acoma Indians also belong, but according to their own tradition they are of mixed stock from the older pueblos. Their town is a relatively new settlement, dating back to about 1697, when it was established with the name San Jose de la Laguna, by Gov. Cubero. The village is built on ledges of buff sandstone on the north bank of San Jose River, which the Indians at that time called the Cubero. This stream affords water for domestic use as well as for the irrigation of small areas of various kinds of crops on which the natives subsist. The Indians had a Spanish grant of over a quarter of a million acres, most of which, however, was desert land. Around their principal pueblo, Laguna, they had many small villages, in which they lived during the summer. Of late years they have occupied some of these villages (Paquate, Negra, Encino, and Casa Blanca) permanently. About 1,800 Indians live in or near Laguna.

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[1] The origin of gypsum deposits of this character is a problem of considerable interest, for the precise conditions of deposition are not known. It is believed that the gypsum was deposited during the evaporation of an inland sea that probably occupied a region of considerable extent in the central United States during later Carboniferous and early Mesozoic time. The thickness of the deposit together with its freedom from admixture with the sand and clays which constitute the rocks overlying and underlying it is remarkable, doubtless indicating that the area of deposition was remote from streams that could bring mud and sand into the sea. For this reason it is believed that the deposit was laid down at a time of scanty rainfall, when the waters of the sea were evaporating rapidly. Waters of this kind were also very salty, but in the course of their evaporation the gypsum was first deposited and the salt later, as the drying up continued. However, no salt deposits have been discovered in connection with the gypsum in this portion of New Mexico. Very salty waters emerge from some of the lower strata of the underlying red beds at various points, indicating that deposition of salt went on during part of the general period, but most of this salt is in rocks that were laid down prior to the thick deposit of gypsum which is so conspicuous at Rito, Rosario, and other places.

The red sandstones overlying the gypsum at Rito, together with a thick body of overlying buff sandstone, probably represents the lower part of the Zuni sandstones. This buff, massive sandstone is conspicuous in the bluffs north and northeast of Suwanee (see fig. 17), as well as in extensive railway and stream cuts along the valley west of Rito, notably near Laguna station and for some distance west. The red sandstone becomes very thin northeast of Suwanee and it also thins toward the south.

On both sides of the valley of San Jose River at Laguna, and along the branch canyons from the north and south, are high mesas with cliffs of sandstone. The beds lie nearly horizontal. The mesas are capped by gray to buff sandstones (Dakota and younger), while the lower cliffs are of massive buff Zuni sandstone. In the intermediate slopes there are extensive exposures of the pale greenish-gray clays, as in other sections east, which extend along the sides of the valley for some distance west beyond Cubero (koo-bay′ro) siding.

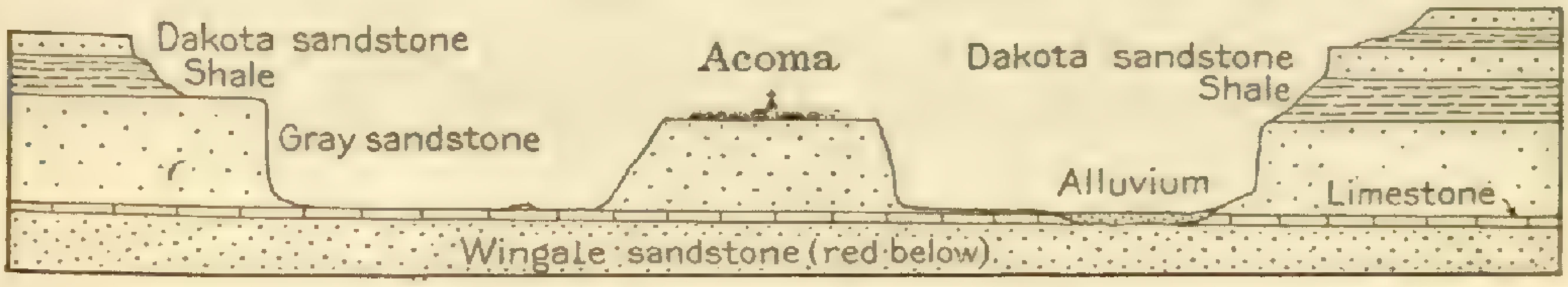


FIGURE 19.—Sketch section through Acoma, N. Mex., looking south.

A short distance southwest of Laguna there comes in from the south a large valley, which heads in the vicinity of Acoma, one of the most remarkable Indian pueblos in the Southwest. As shown in Plate XV (p. 97), this place is built on top of a high, isolated mesa with precipitous walls of gray sandstone (see fig. 19) and has been an object of great interest to travelers ever since the first visit of Coronado. It is notable as the oldest continuously inhabited settlement in the United States. Unlike most of the other pueblo villages, Acoma is recorded in the early chronicles as the home of a people feared by the residents of the whole country around as robbers and warriors. Its location upon a precipitous white rock (Akome, "people of the white rock") rendered it well-nigh impregnable to native enemies as well as to Spanish conquerors, for the only means of approaching it was by climbing up an easily guarded cleft in the rock. However, one of the Spanish expeditions, with 70 men, succeeded in killing 1,500 of these Indians—half their total number—in a three-day battle in 1599. The entrance and stairway in use now are the same that were described by Alvarado on his visit with Coronado's expedition in 1540. The height of the mesa is 350 feet. The Acoma people are expert makers of pottery, as are also the Laguna Indians.

A short distance north of Acoma is the famous Mesa Encantada (enchanted mesa), shown in Plate XIV, *A*, on which was located, according to the tradition of the Acomas, their prehistoric village of Katzimo.

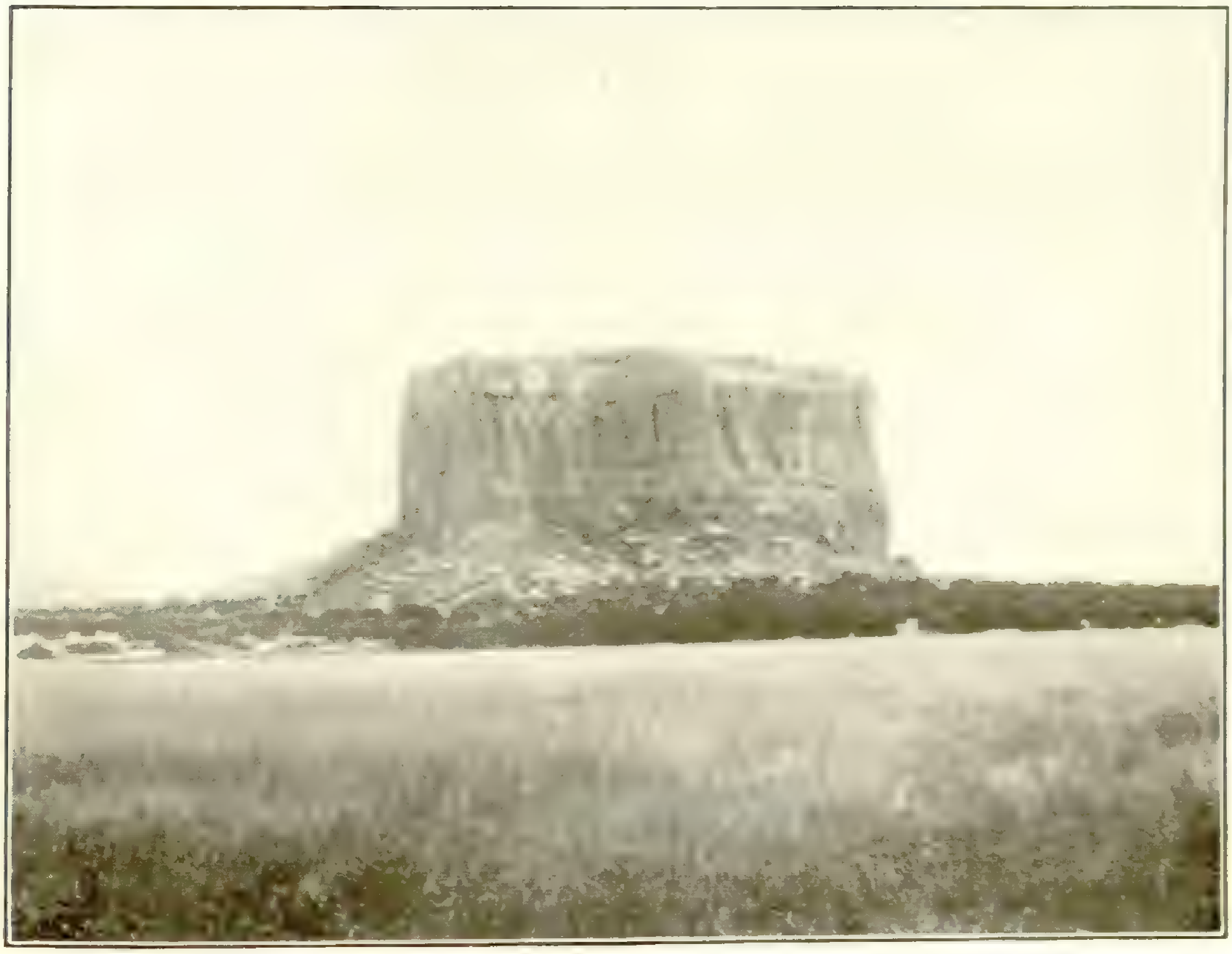
Acoma is easily reached from Laguna by a drive of 18 miles, for which a team and Indian driver can usually be obtained at Laguna. It will be found that the Indians of Acoma are rather indifferent to the desire of the tourist to see the sights of the place unless some remuneration is offered. The large church, built mainly of slabs of rock, is still in excellent condition, although it was built about 1699. The New Mexico building at the Panama-California Exposition at San Diego is patterned after this church, with the portico modified after the church at Cochiti. The population in 1902 was 566.

West from Laguna the railway continues to ascend the valley of the San Jose. This stream for part of the year furnishes water for a small amount of irrigation, mostly by the Indians of the Acoma tribe, who maintain summer villages at different places.

Cubero.
Elevation 5,929 feet.
Population 515.*
Kansas City 993 miles.

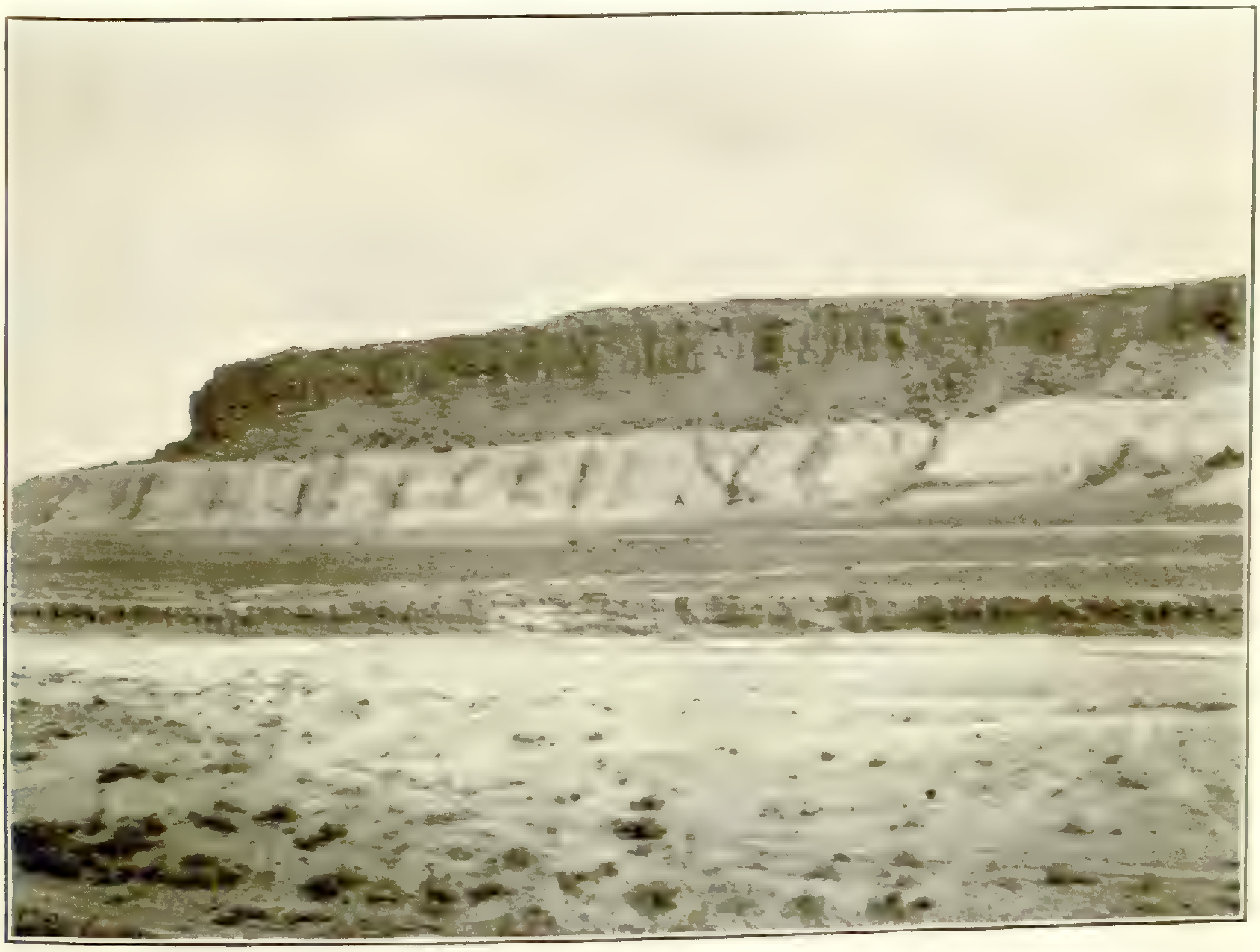
At Cubero, now a small Mexican village, there was formerly a pueblo of San Felipe Indians, who now live near Santo Domingo. The name Cubero is that of the Spanish governor in office at the end of the seventeenth century. The real town of Cubero, a Mexican settlement, is 8 miles to the northeast. There are many Penitentes in these villages. About 2 miles beyond Cubero, near milepost 74, there is a view up the valley in which the pueblo of Acoma and the Mesa Encantada are situated, about 10 miles to the south in an air line. On both sides of the San Jose Valley are high walls of the Dakota and Mancos sandstones, which lie nearly horizontal, so that the railway rises to higher and higher beds as it ascends the valley.

Near milepost 77, 5 miles west of Cubero siding, there is to the north a fine view of Mount Taylor, a huge cone standing on a high plateau of sandstone and lava. It was named for President Zachary Taylor, but this name has not entirely displaced the local name, Sierra San Mateo. This mountain is an isolated mass consisting largely of gray lava (andesite) and represents an eruption of considerable antiquity, much older than the sheets of black lava (basalt) which cap the plateaus or mesas along the north side of the valley. Since these early lava outflows the valleys have been cut to their present depths of 1,500 to 2,000 feet and a considerable area of the plateaus has also been removed, as shown in figure 20. Mount



A. MESA ENCANTADA, N. MEX., SEEN FROM THE NORTH.

The mesa is about 350 feet high, and its width is about one-third its length. The rock is buff massive sandstone of the lower part of the Zuni formation.



B. BED OF GYPSUM AT RITO, N. MEX.

View northward. The bed is 50 feet thick and lies under red sandstone opposite the Indian pueblo just north of the Atchison, Topeka & Santa Fe Railway. The base of the gypsum bed (A) rests on limestone.

PUEBLO OF ACOMA, N. MEX.

Church in center. The pueblo stands on a high mesa of massive buff sandstone of the lower part of the Zuni formation. Shows wind-blown sand sloping upward nearly to the top of the mesa.

Taylor is held in great veneration by the Pueblo Indians, who call it the "mother of the rain." In the spring a party of them usually goes to its top for sacred dances to invoke the rain god for a plentiful harvest.

A short distance south of the track near milepost 77 is the small pueblo of Acomita, which belongs to the Acoma Indians and serves as a home for about 200 of them during the summer when they are cultivating the fields in the bottom of the valley. There is a United States Indian school here and a good road southward to Acoma.

Alaska.

Elevation 6,041 feet.
Kansas City 999 miles.

Mount Taylor is again visible from Alaska siding and west from that place for a mile or two. The platform from which it rises is covered by a sheet of black lava (basalt) capping cliffs and long slopes of the later Cretaceous sandstones. Far to the south rise extensive high plateaus occupying the region west of Acoma.

Halfway between mileposts 80 and 81, the lava sheet in the bottom of the valley is plainly visible. The lava flowed out of vents in the region to the west at a time much later than that of the eruption of the lava sheet which caps the mesa that extends along the north side of the valley from Laguna westward. At milepost 81 there is an exceptionally good view of Mount Taylor.

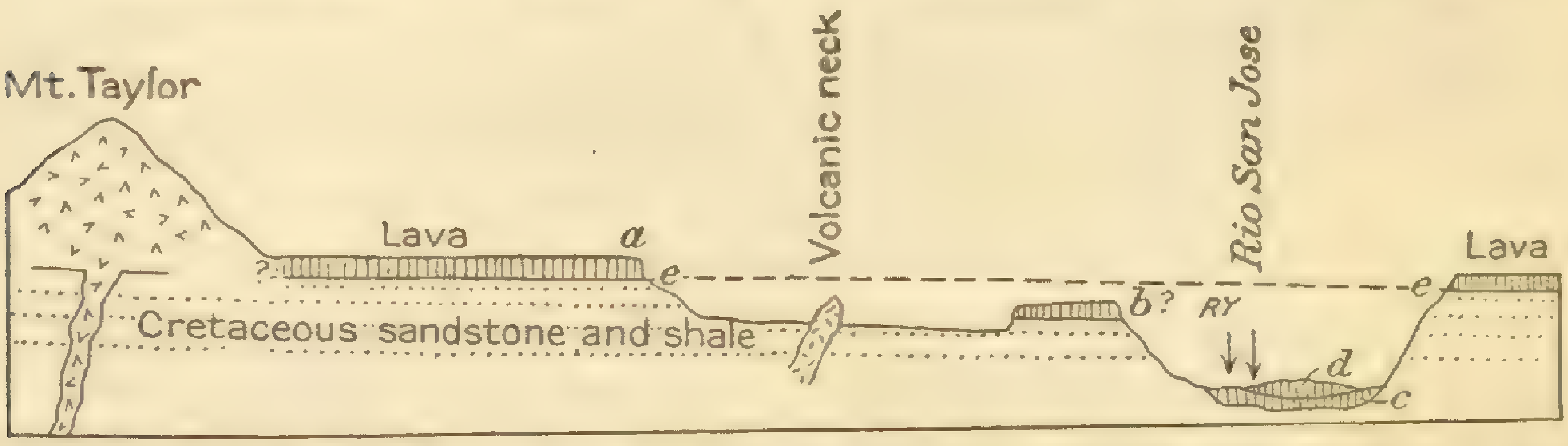


FIGURE 20.—Sketch section showing relations of lava sheets near Mount Taylor, N. Mex. *a*, *b*, *c*, *d* Four successive lava flows later than flow in Mount Taylor; *e–e*, former surface of plateau before valley of San Jose River was excavated.

McCartys.

Elevation 6,041 feet.
Kansas City 1,002 miles.

McCartys is a trading center for ranches and the Indians in the San Jose Valley and adjoining region. At Acoma siding (see sheet 15, p. 104), 2½ miles west of McCartys, there is an Indian village of moderate size on the south side of the valley, used as a summer home by some of the Acoma Indians.

In the bottom of the valley, a short distance beyond Acoma siding, is the termination of a lava flow that is evidently more recent than the lava that occupies the valley farther east. The railway extends along its northern margin for several miles, affording excellent views of the rocks which present features characteristic of recent flows from some of the great volcanoes in various parts of the earth. The sheet is narrow, for the sandstone walls of the canyon are not far apart in this region. The surface of the lava is exceedingly rough, parts of it having been shattered into large fragments by the flow movement, and other parts consisting of great blisters, mostly broken and showing caverns underneath. Much of the smoother surface of the lava is black and ropy, very similar to slag from a blast furnace. There is but little vegetation over its surface, and all its features indicate that it is a relatively very recent flow. Some of the Pueblo Indians of the region have a legend, handed down for several generations, of a river of fire in San Jose Valley, and it seems not unlikely that the forefathers of these people witnessed this outflow. It is said that the lava has flowed around the corner of an old stone wall at one point above McCartys, but on inspection of this wall it appears more likely that the wall was built into an angular jog in the margin of the sheet. This lava flow extends 20 miles up the valley, and except for a short distance near milepost 89 the railway is close to its northern edge. As the valley widens beyond Horace the lava sheet spreads out to the south, and probably it came from cones which are visible in that direction.

Horace.
Elevation 6,321 feet.
Kansas City 1,012 miles.

Near milepost 90 the beds of rock in the canyon walls begin to rise gradually toward the west, and the Dakota sandstone and underlying beds, including the massive gray sandstone seen near Laguna and Acoma, appear again. These rocks extend along the base of the cliffs far to the north and south of the railway. The rise of the beds continues past Horace siding for 1½ miles to milepost 92, where a sandstone butte north of the track shows the beds dipping eastward at angles between 5° and 10°.

Just north of Horace the sandstone mesa north of the track is 300 or 400 feet high and capped by a thick sheet of older lava (basalt), which extends for a considerable distance east and west. This mesa finally bears off to the northwest as the valley widens, and a corresponding cliff extends south. Four miles west of Horace the valley is several miles wide and the greater part of its bottom is occupied by the very recent lava flow mentioned above.

Grant.
Elevation 6,464 feet.
Kansas City 1,017 miles.

Grant is a local center for ranch and stock interests in the adjoining region. Just north of Grant is a lava-capped mesa which continues about 5 miles west, gradually bearing off to the north. In places the edge of the lava shows columnar structure. South of the track there are good exposures of the recent lava sheet above referred to, showing a large amount of very rough surface with great broken blister cracks and much ropy lava.

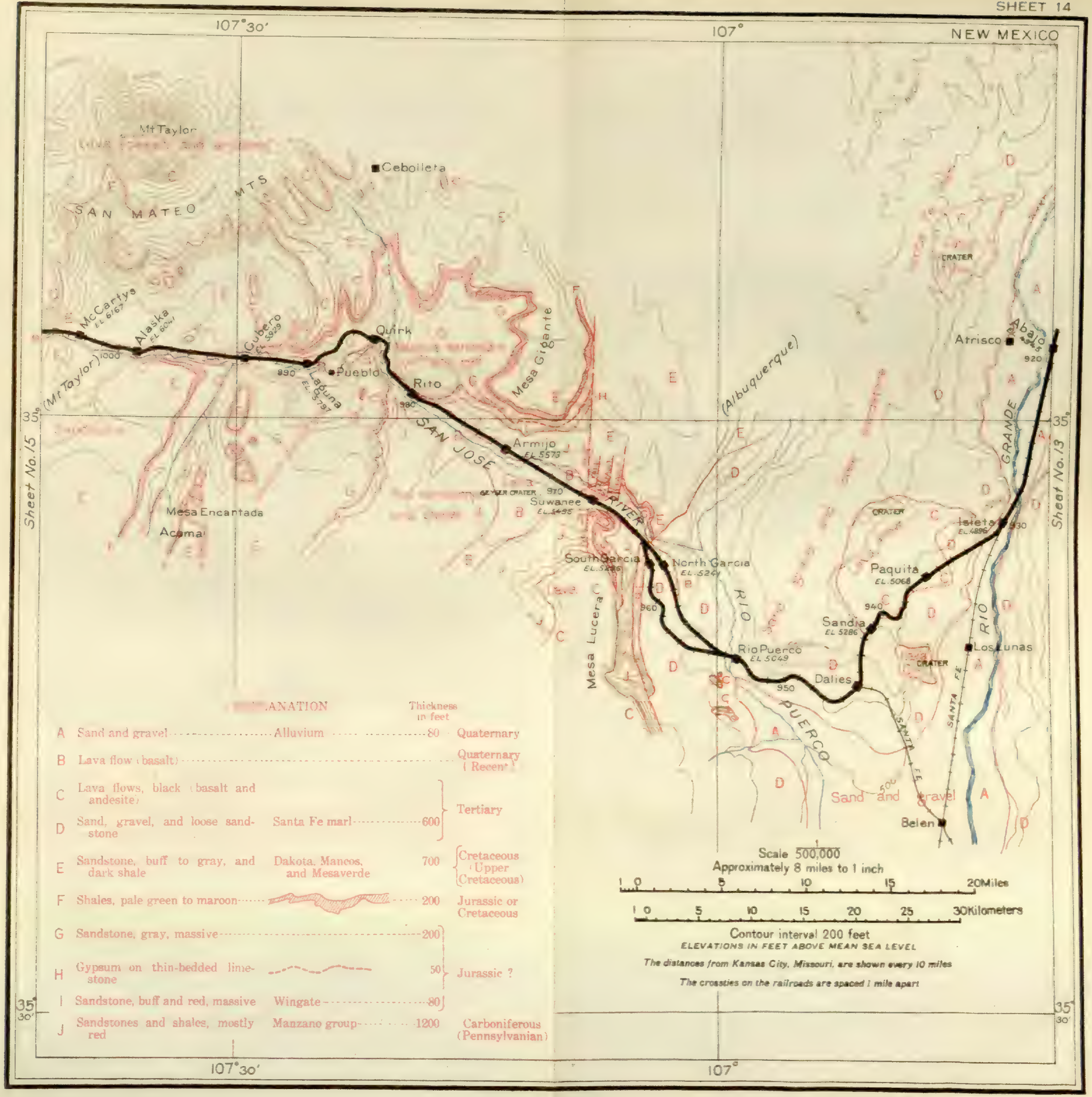
A few miles west of Grant the Zuni (zoon′ye) Mountains are in sight to the west. These mountains are the result of an extensive dome-shaped uplift of the earth's crust. In its higher central part, from which the sedimentary rocks have been removed, the old granites and

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
SANTA FE ROUTE
From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist R. B. Marshall, Chief Geographer
1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.


NEW MEXICO
107°30'
107°
35°
35° 30'
Sheet No. 15
Sheet No. 13
Mt Taylor
SAN MATEO MTS
Ceboileta
McCartys EL 6167
Alaska EL 6041
Cubero EL 5929
(Mt Taylor)
1000
890
Laguna EL 5797
Pueblo
Quirk
Rito
980
Mesa Gigante
SAN JOSE RIVER
Armijo EL 5573
GEYSER CRATER
970
Suwanee EL 5455
Mesa Encantada
Acoma
(Albuquerque)
South Garcia EL 5285
North Garcia EL 5241
960
Mesa Lucera
RIO PUERCO
Rio Puerco EL 5049
950
Dalies
Sandia EL 5286
940
Paquita EL 5068
Isleta EL 4896
930
Atrisco
Abajo
920
RIO GRANDE
CRATER
Los Lunas
SANTA FE
Belen
500
Sand and gravel
A
B
C
D
E
F
H
EXPLANATION
Thickness in feet
A Sand and gravel ······ Alluvium ······ 80 Quaternary
B Lava flow (basalt) ······ Quaternary (Recent)
C Lava flows, black (basalt and andesite) Tertiary
D Sand, gravel, and loose sandstone Santa Fe marl ······ 600
E Sandstone, buff to gray, and dark shale Dakota, Mancos, and Mesaverde 700 Cretaceous (Upper Cretaceous)
F Shales, pale green to maroon ······ 200 Jurassic or Cretaceous
G Sandstone, gray, massive ······ 200
H Gypsum on thin-bedded limestone 50 Jurassic ?
I Sandstone, buff and red, massive Wingate ······ 80
J Sandstones and shales, mostly red Manzano group ······ 1200 Carboniferous (Pennsylvanian)
Scale 1/500,000
Approximately 8 miles to 1 inch
0 5 10 15 20 Miles
0 5 10 15 20 25 30 Kilometers
Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart

schists appear, constituting a group of high summits of considerable prominence. One of these, Mount Sedgwick, has an altitude of 9,200 feet. The Zuni Mountains extend westward along the south side of the San Jose Valley and across the Continental Divide nearly to Gallup, the railway deflecting its course somewhat to the northwest to pass around their foothills. Many features of the limestone ridge on the northeast slope of this uplift are visible between Grant and Bluewater stations, including some deep canyons rimmed with high cliffs of the white limestone and sandstone of later Carboniferous age. The northeastward dip is plainly perceptible, and the rough, craggy ridges of granite of the interior of the uplift may be discerned, culminating in Mount Sedgwick.

Northeast of the railway a wide valley extends to the foot of low cliffs of red sandstones and gray sandstones (Dakota), with formations of later Cretaceous age farther back. From a point near Bluewater station there are fine views of the west side of Mount Taylor to the east, showing the high lava-capped plateau on which this mountain stands.

Bluewater.
Elevation 6,634 feet.
Population 237.*
Kansas City 1,028 miles.

South of Bluewater is a Mormon settlement using water from Bluewater Canyon to irrigate fruits, alfalfa, and vegetables. Three miles north by east of Bluewater station there rises on the valley slope a round black cone of moderate elevation, known as El Tintero (tin-tay′ro, Spanish for ink pot), from the deep hole or crater in its top. It is shown in Plate XVI, *B* (p. 100). The lava flow flooring San Jose Valley at Horace and Grant extends to this cone, which perhaps marks a source of the outflow. El Tintero is plainly in view to the north of the track for several miles, or nearly to milepost 110, where the lava ceases and is succeeded by red and gray shale of Triassic age. The shale represents some of the red shales and sandstones which overlie the massive sandstone of the midde of the red beds in the Glorieta region, between Las Vegas and Lamy.

A short distance southeast of the railway low knobs mark the outcrop of sandstone (Shinarump?) underlying this shale, and a short distance farther south still lower limestones, of Carboniferous age, rise gradually on the northeast slope of the Zuni uplift.

From milepost 110 to the Continental Divide at Gonzales and thence down the west slope for 20 miles farther the railway is built through a broad valley underlain by the soft red and gray shale above mentioned. This valley extends northward for 2 or 3 miles to the foot of walls of bright-red sandstones (Wingate), mostly 300 to 400 feet high, capped by lighter-colored sandstones (the Zuni and Dakota) which rise as great steps to a ridge of considerable prominence extending continuously across the Continental Divide. This red wall is recessed by numerous small canyons, and some of the intervening buttresses are carved into a great variety of massive forms. These very conspicuous and beautiful features continue in sight for a long distance along the north slope of the Zuni uplift.

The strata appear to be horizontal, but they dip at low angle to the northeast or at right angles to the line of the railway.

Figure 21, a section near the Continental Divide, shows the succession of beds on the slopes of the Zuni Mountains south of the railway and in the walls of red sandstone and overlying rocks to the north.

Thoreau.

Elevation 7,135 feet.
Population 286.*
Kansas City 1,047 miles.

In the region about Thoreau the principal industry is the raising of sheep, goats, and cattle. Many Navajo Indians, engaged mainly in goat raising, live in the country to the north. This is the place from which the extensive prehistoric ruins of Chaco Canyon, 50 miles to the north, are reached. One of these ruins, now called Pueblo Bonito, was a house of about 1,000 rooms. At Thoreau and for the next few miles beyond there are especially fine views of the great cliffs of red Wingate sandstone to the north.

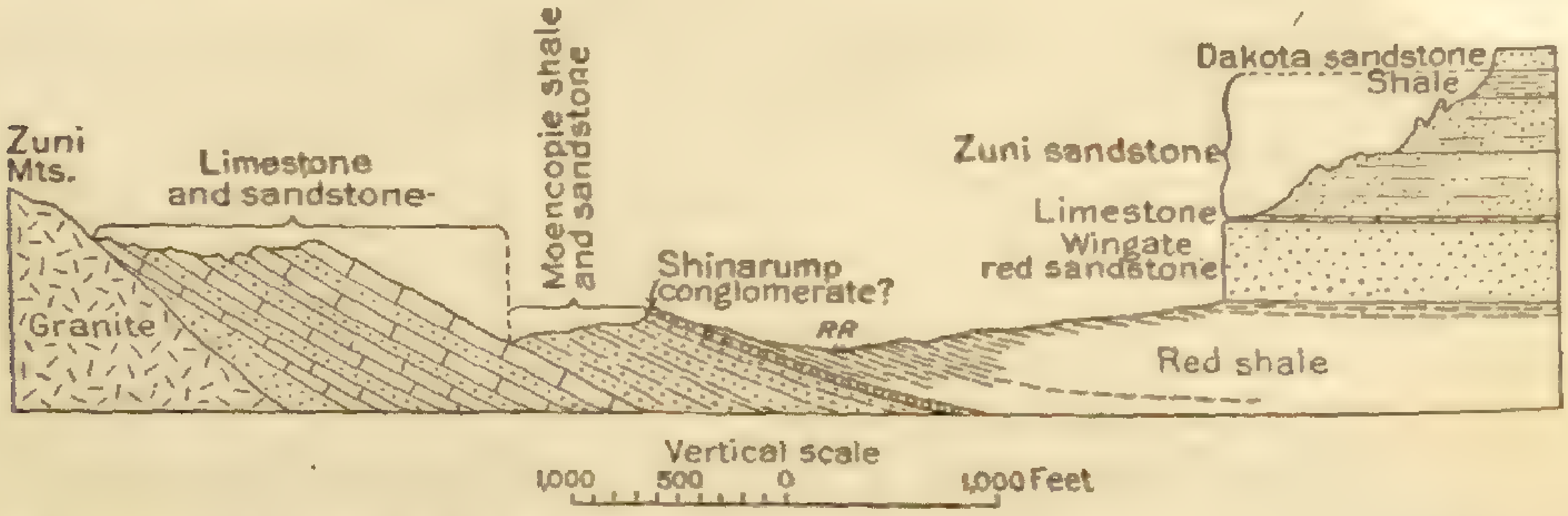


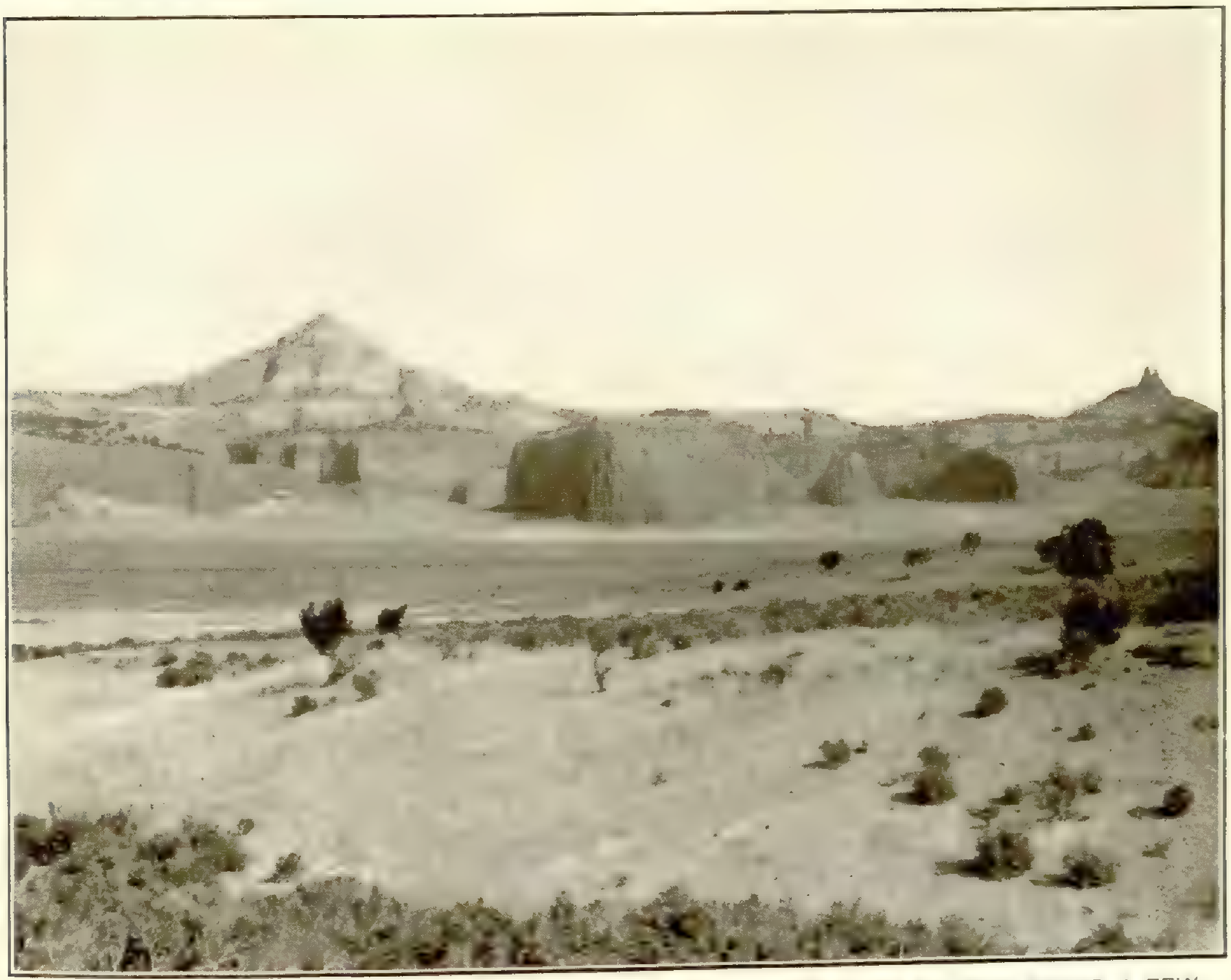
FIGURE 21.—Section from the Zuni Mountains northward across the Santa Fe Railway near Thoreau, N. Mex., looking northwest.

Gonzales.

Elevation 7,250 feet.
Kansas City 1,051 miles.

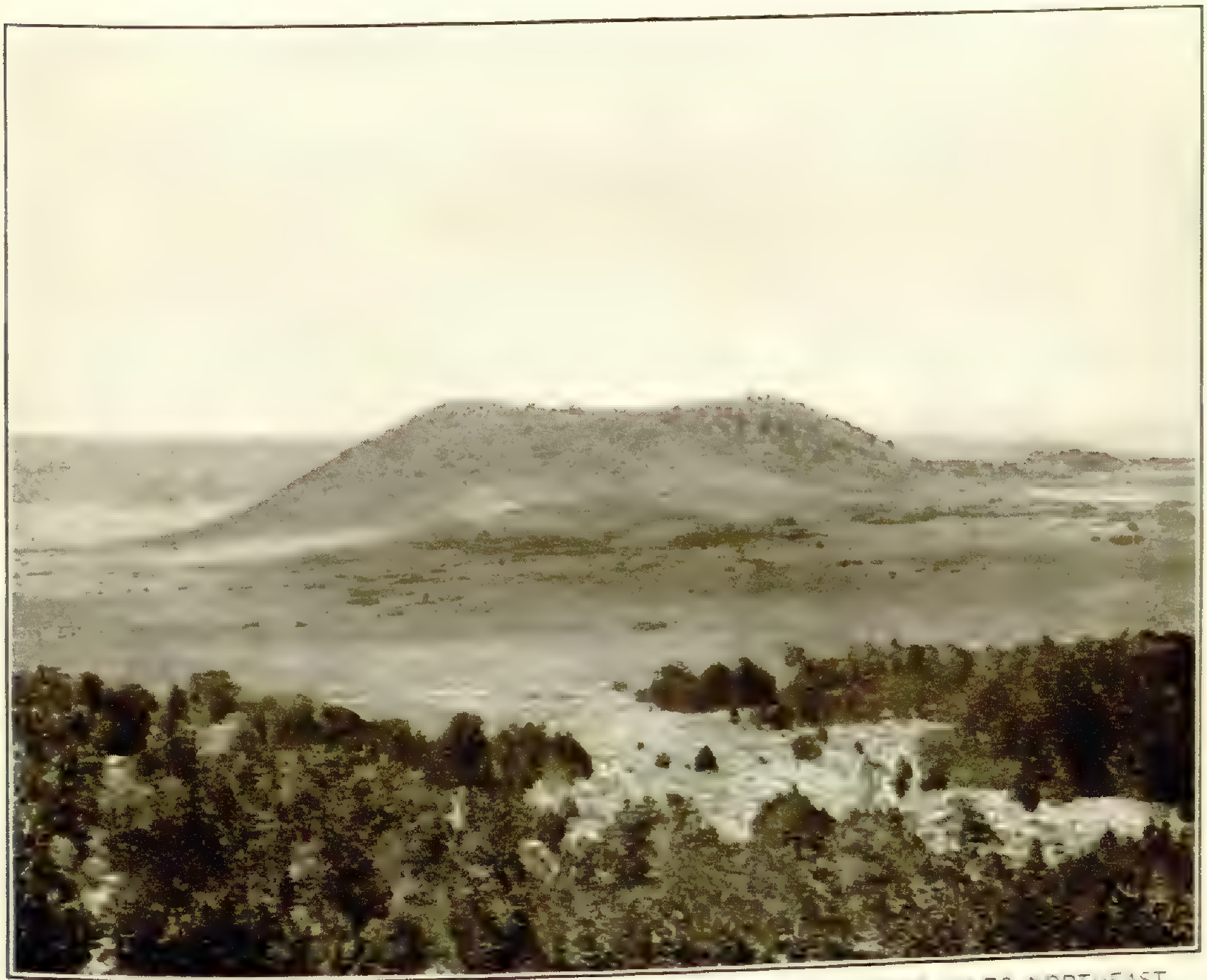
The climb up to the Continental Divide is made on a very moderate grade, about 21 feet to the mile. There is no mountain top to be attained, for the divide is in a broad east-west depression known as Campbells Pass. The summit, which is reached at Gonzales siding, halfway between mileposts 130 and 131, is at an altitude of 7,250 feet, or 358 feet lower than Raton Pass. A large sign erected just north of the track states that the Continental Divide is crossed at this place. This divide, which crosses the Zuni Mountains to the south and passes over the high cliffs to the north, separates the waters of San Jose River and the Rio Puerco, affluents of the Rio Grande, from those of the Rio Puerco (of the West), a branch of the Little Colorado, which flows into the Colorado and so empties into the Pacific Ocean.

West of Gonzales there are two lines as far as Perea; the westbound trains take the left-hand track and pass through South Guam siding, halfway between mileposts 136 and 137. In this vicinity the great red wall to the north is a prominent feature, and to the south rise the long slopes of sandstone and limestone leading up to the



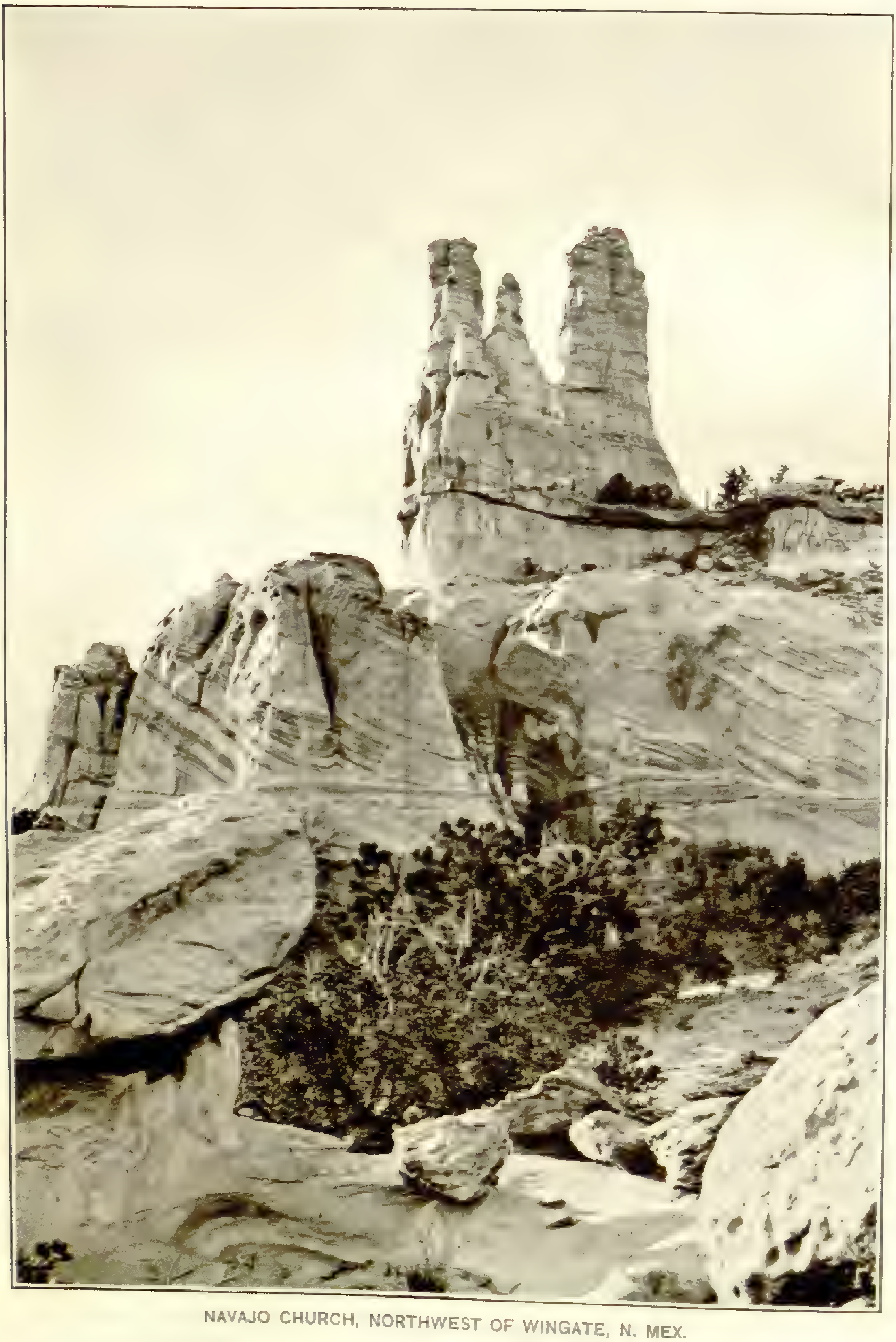
A. PYRAMID ROCK AND RED CLIFF OF WINGATE SANDSTONE NORTH OF ZUNI SIDING, A FEW MILES EAST OF GALLUP, N. MEX.

View northeastward. Navajo Church at extreme right. Santa Fe Railway in middle distance.



B. EL TINTERO, A VOLCANIC CONE WITH A CRATER IN ITS TOP, THREE MILES NORTHEAST OF BLUEWATER STATION, N. MEX.

View northeastward over fields of lava ejected from a vent at this place.



NAVAJO CHURCH, NORTHWEST OF WINGATE, N. MEX.

Carved by rain and wind-blown sand in white Zuni sandstone. Note cross-bedding.

wooded summit of the Zuni Mountains. A small ridge, constituting a foothill to these mountains is due to the outcrop of the bed of coarse Shinarump sandstone which lies beneath the shales of the wide valley followed by the railway.

The wall of red Wingate sandstone 2 miles north of Perea siding is broken into numerous massive buttresses, which rise to a high shelf of moderate width extending back to still higher steps of lighter-colored sandstones and shale (the Zuni), capped by the Dakota sandstone far in the background. These features continue in view to Wingate station.

Wingate.
Elevation 6,743 feet.
Kansas City 1,067 miles.

Wingate is the station for old Fort Wingate, which is 3 miles due south of it. Until recently this fort was sustained by the Government as a military depot, with several regiments ready for active duty. During part of 1914 the old buildings were used for housing the 4,000 Mexican Federal troops and their families who were forced into Texas at Eagle Pass. These people were employed in working roads in the vicinity.

The traveler is here well within the land of the Navajo (nav'a-ho) Indians, now peaceful blanket makers, herders, and farmers, but for a long time one of the predatory savage tribes, the terror of the Pueblo people and their ancestors.[1]

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[1] The Navajos were wily warriors, and usually their raids or other depredations were victorious. After the acquisition of the Southwest by the United States, they killed many citizens, especially when the frontier troops were withdrawn to participate in the Civil War. Several attempts were made to subdue the Navajos, but none succeeded until 1863, when Col. Kit Carson drove them into eastern New Mexico, where they were held as prisoners until 1867. Then they were permitted to return to their old haunts in western New Mexico and northeastern Arizona, where a large reservation was apportioned to them. Since that time they have been peaceful and in some ways prosperous. It is estimated that the warfare against the Navajos and Apaches from 1849 to 1886 cost the United States $50,000,000.

The Navajo Reservation covers more than 9,000,000 acres, most of it above an altitude of 6,000 feet. Its southeastern corner is 20 miles northeast of Wingate, its southwest corner is a short distance west of Canyon Diablo, in Arizona, and it has a length of about 190 miles. This is an area of about 15,000 square miles, which is greater than Massachusetts and New Jersey together. The Navajos number about 30,000. Their number has been steadily increasing for many years; it was 9,000 when they were counted in 1869. They were not mentioned by travelers prior to 1629, and apparently began as a small offshoot of the Apaches. They call themselves Dinneh, meaning "the people." The Spaniards called them "Apaches de Navajó," from Navahu, the name of an old Tigua pueblo in the vicinity of which they lived. Most of them live in temporary hogans, built simply of sticks covered by earth and branches, and they frequently move from place to place. Usually a few families live near together, and they congregate about watering places and trading posts. The women weave their famous blankets, which bring them nearly $500,000 a year, and men and boys tend their sheep and goats and raise a few crops. They live a life closely adjusted to their environment, and with very few requirements beyond the simplest necessities. They

West of Wingate the railway continues along the red shale valley but gradually approaches much nearer to the foot of the great red cliffs than in the region farther east, affording particularly good views of some of their picturesque features. Due north of milepost 150 a remarkable rocky pinnacle, known as the Navajo Church (see Pl. XVII), may be seen. Its sharp spires of white sandstone, about 200 feet high, rise conspicuously above the rocky slopes at the top of the walls of red sandstone. It is a striking object, fashioned by the irregular erosion of the massive Zuni sandstone by rain and frost, and in some measure also by wind-blown sand. A short distance to the west is Pyramid Rock (shown in Pl. XVI, *A*), a conical mass of the same material.

Not far west of Zuni siding (milepost 152) the axis of the arch of the Zuni uplift is crossed, the beds on its crest pitching steeply to the northwest. West of the axis the beds all dip steeply to the west and southwest. This feature may be observed between mileposts 153 and 155, especially at the latter, where the railroad and creek pass through a narrow gap having walls of nearly vertical beds of the Dakota and overlying sandstones, as shown in Plate XVIII. This steep dip to the west carries these sandstones underground within a short distance, beneath coal-bearing sandstones that occupy a shallow basin to the west. (See Pl. XIX, *A*.) The change of dip from nearly vertical to horizontal is so rapid as to give the appearance of a fault in the slope north of the railway, but close scrutiny has shown that there is no appreciable break. The relations of this flexure are shown in figure 22.

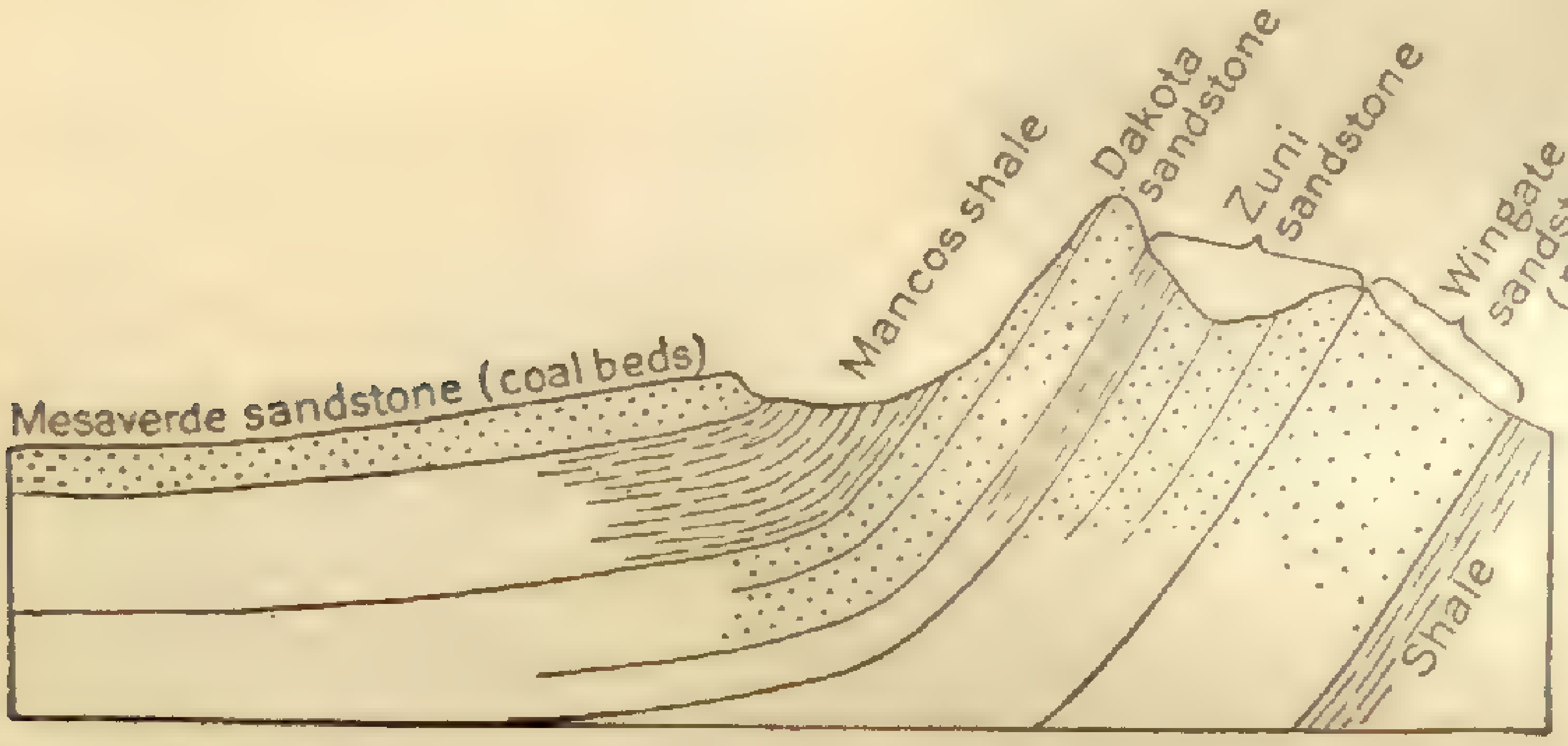

FIGURE 22.—Section of coal-bearing Mesaverde formation, Dakota sandstone, and underlying beds in and near the gap 3 miles east of Gallup, N. Mex.

The narrow zone of steep dips extends all along the west side of the Zuni uplift, and the ridge marking its course may be seen bearing off to the south from the vicinity of milepost 156. The basin west of

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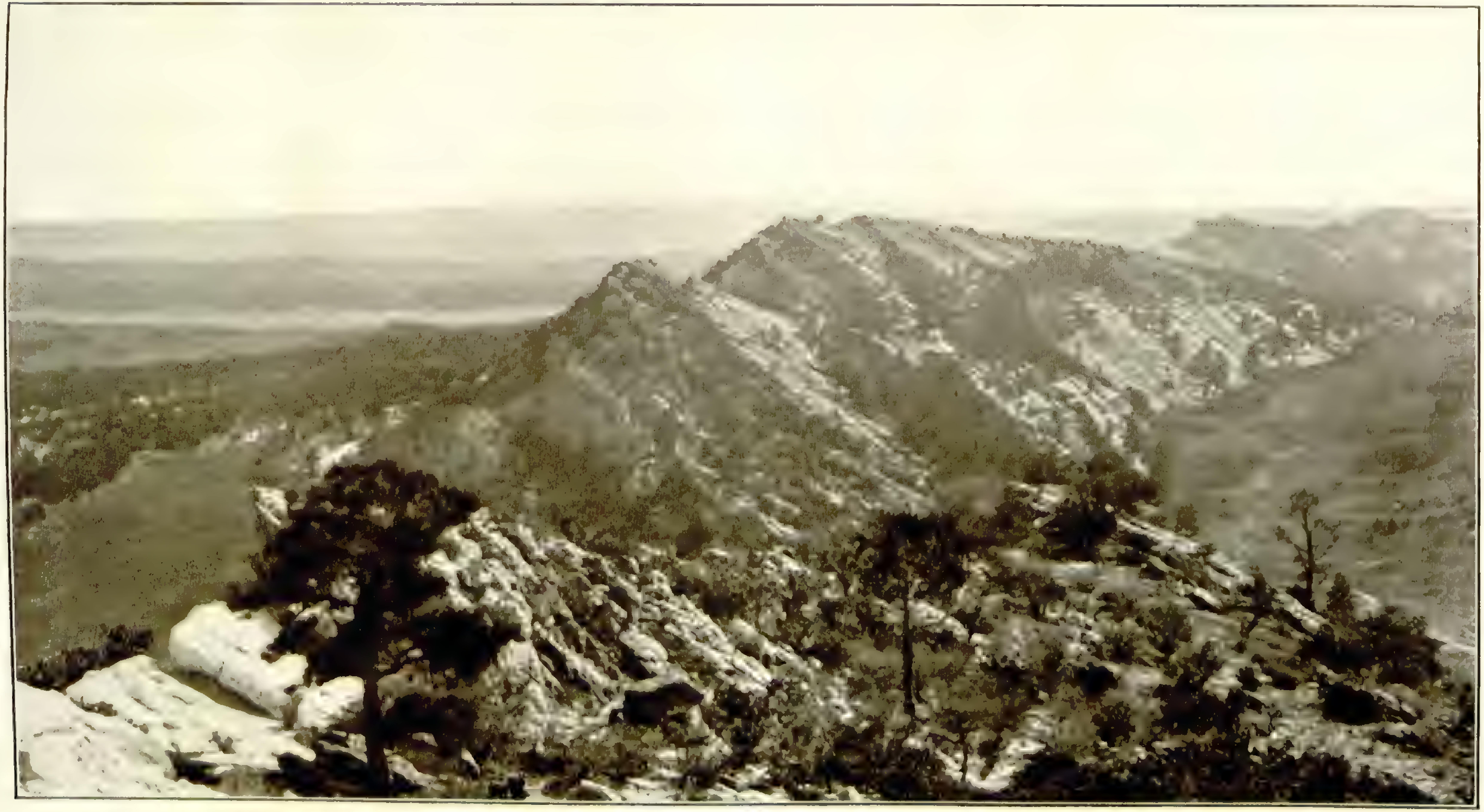
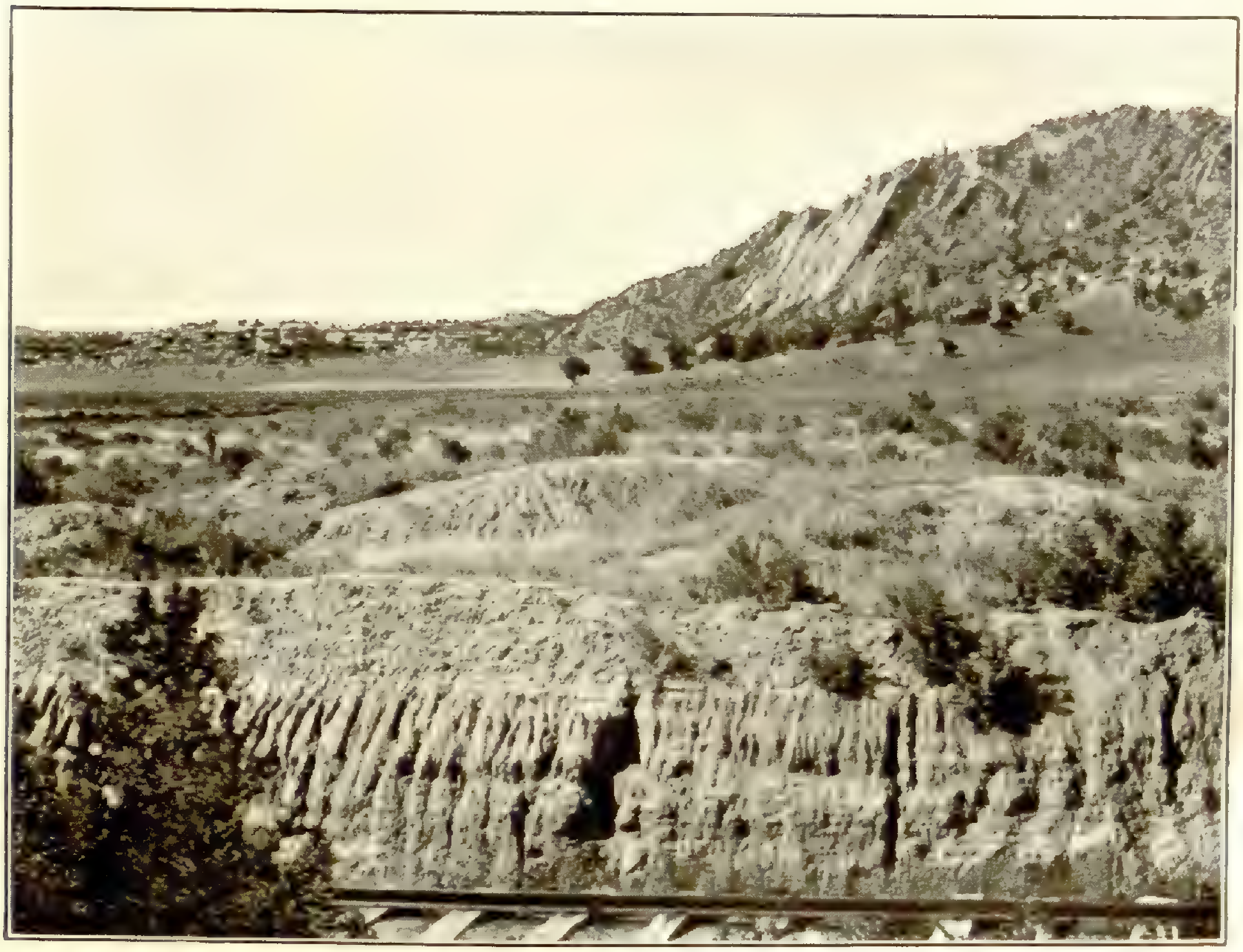
own about 30,000 cattle, 1,400,000 sheep, 320,000 goats, and 250,000 horses, burros, and mules. In 1914 they sold 3,375,000 pounds of wool from native sheep, and 293,463 pounds of merino wool, valued in all at $465,000.

Despite their history as predatory savages, the Navajos are in general jovial, truthful, intelligent, and, as Indians go, industrious and capable. They have an ample vocabulary, a complex grammar, an elaborate religious system, and hundreds of songs. They have numerous schools scattered widely over the reservation, and many of them are eager to have their children attend. About 10 per cent have tuberculosis, and 20 per cent have trachoma, a contagious eye affection.



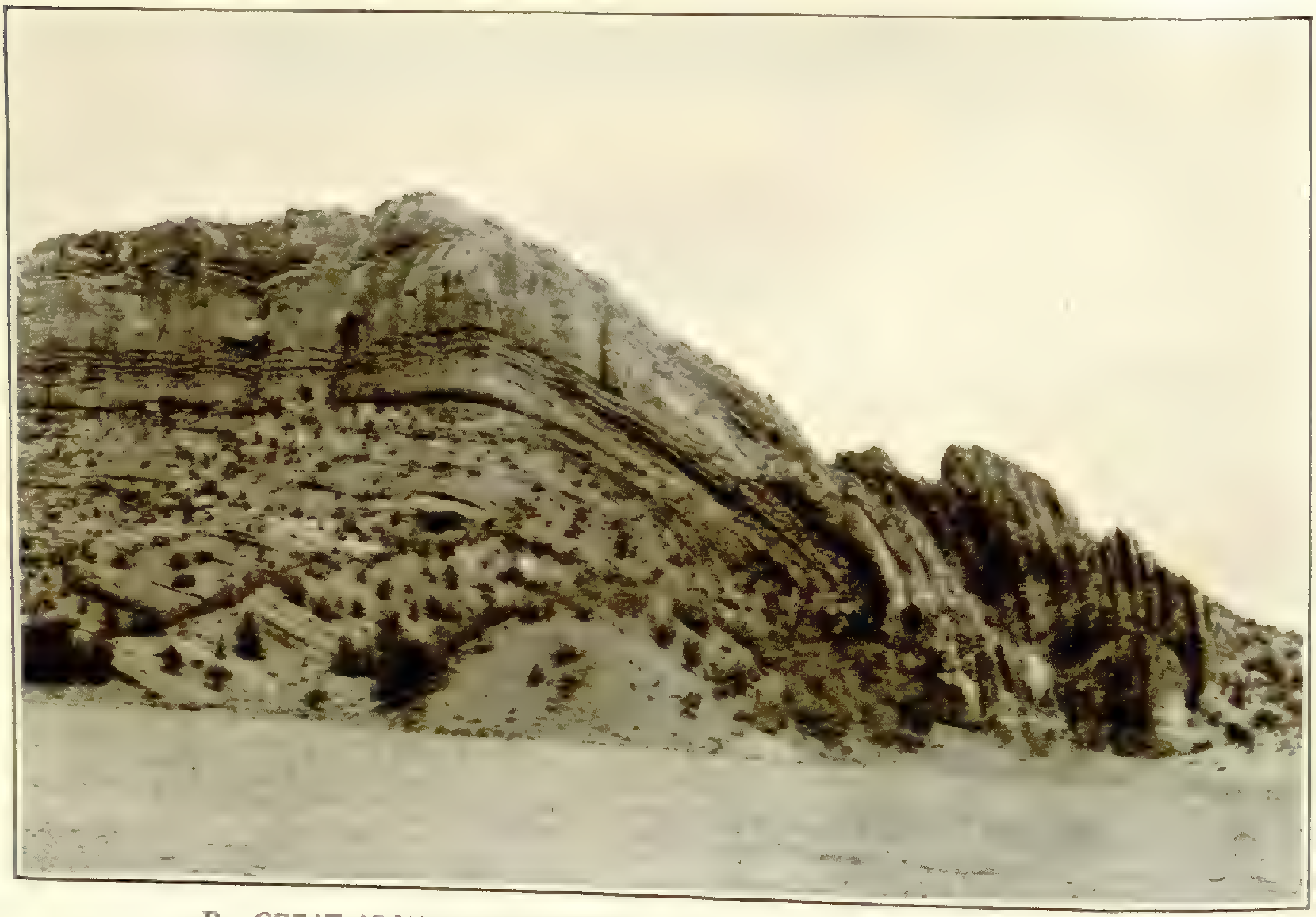
TILTED BEDS OF SANDSTONE DIPPING WEST ON WEST SLOPE OF ZUNI UPLIFT, THREE MILES EAST OF GALLUP, N. MEX.

View southward. Valley of Mancos shale to the right.



.1. SHARP BEND .N BOUNDARY OF ZUNI MOUNTAIN UPLIFT AS SEEN FROM SANTA FE RAILWAY THREE MILES EAST OF GALLUP, N. MEX.

View northward Nearly horizontal coal measures (Mesaverde formation) at left of center of view, in background.



B. GREAT ARCH IN THE RED SANDSTONE NORTH OF HOUCK, ARIZ.

View northward.

this uplift contains an extensive area of sandstones and shales of later Cretaceous age (Mesaverde), including several beds of excellent subbituminous coal which are worked at a number of places.

Gallup.

Elevation 6,503 feet.
Population 2,204.
Kansas City 1,079 miles.

Gallup is a railway division point and meal station. Its principal industry is coal mining and most of the mines are in the immediate vicinity of the town.[1] There are also two brick kilns that make a large output. Many cattle, sheep, and goats are raised in the adjoining country. A large number of Navajo and Zuni Indians come to Gallup to trade and each year bring in an increasing amount of wool for sale. Formerly they received their pay in merchandise, but now the clip of wool is so large that they receive considerable balances in cash. The Navajo Reservation is a short distance north of Gallup and 40 miles to the south is Zuni, one of the largest pueblos in the Southwest. This place is visited by many persons and is easy of access by vehicles from Gallup over fairly good roads. At Zuni there are ample facilities for taking care of visitors overnight. A special occasion is the Shalako dance, usually held in November.

Zuni is one of the famous seven cities of Cibola, the objective point of the Spanish expedition under Coronado in 1540. The largest of these seven pueblos contained about 500 rooms. Some of the ruins of old Cibola are still to be seen. Near Zuni is the precipitous-sided mesa of Toyalane, to which the Indians of this tribe fled whenever they feared invasion or punishment, remaining there sometimes for many years, while their abandoned pueblos fell to ruins. The present pueblo of Zuni was built 200 years ago, and here was concentrated what remained of the people of Cibola. The United States has recently built a dam to hold water for irrigation at Zuni, an undertaking which is greatly appreciated by these progressive and prosperous Indians. Their population, which is 1,640, has remained about the same for the last 30 years.

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[1] The coal that is extensively mined about Gallup is a subbituminous coal (formerly known as black lignite), which occurs mainly in a bed 5½ feet thick, contained in the Mesaverde formation. It is used on locomotives and shipped great distances along the railway for manufacturing and domestic use. Its keeping qualities, however, are not entirely satisfactory, the coal having a disposition to break up into fine slivers when exposed to the air, on account of the large amount of water it contains. The rapid evaporation of this water from the surface layers causes them to shrink and curl up or scale off and to heat spontaneously when stored for a long time in large quantities. Eventually it will be compressed into briquets, a result which will overcome these unfavorable characteristics. The average Gallup coal contains about 42 per cent of fixed carbon, 40 per cent of volatile combustible matter, 11 per cent of moisture, and 6 per cent of ash. The heating value is 11,700 British thermal units. In 1913 the production of coal from the Gallup region amounted to nearly 825,000 tons, valued at $1,367,364. The coal-bearing series consists of an alternation of sandstone and shale. Ledges of sandstone crop out extensively around Gallup and for some distance west.

At Gallup a large supply of excellent water is obtained from artesian wells sunk through the coal-bearing rocks into the underlying sandstones. Without this underground supply the town would be greatly hampered, for the surface waters in the vicinity are very small in volume and mostly of bad quality. The well water is carried in tank cars to supply many stations along the railway where the local water is not satisfactory.[1]

A coal mine, plainly visible a quarter of a mile north of the track a mile west of Gallup, is one of the large producers of the area. Just south of a point two-tenths of a mile beyond milepost 163, west of West Yard siding (see sheet 16, p. 108), is a knob due to a mass of dark igneous rock (vogesite), cutting the coal-bearing rocks, and another small dike of the same material appears half a mile farther southwest.

At milepost 163 sandstones below the coal measures appear, and a short distance north of milepost 166, which is at Defiance siding, they arch over, forming a well-marked anticline. Beyond this arch the beds dip west for a short distance at moderately steep angles, into a shallow syncline, out of which they rise again on an easterly dip at milepost 167. The easterly dip continues for some distance, bringing up lower and lower beds of the sandstone in succession toward the west. Finally at milepost 176 appears one of the lower sandstones, 200 feet thick, forming a high wall on both sides of the Rio Puerco valley, which in consequence becomes a canyon. These cliffs continue for several miles to the west.

At Manuelito (mahn-way-lee′to) considerable trading is done with the Navajo Indians who live on the reservation a short distance north. This place was named for a Navajo who was elected chief in 1855, when a treaty was arranged with the Navajos to end their depredations. This treaty, however, was not ratified by Congress, and lawlessness continued till the final subjugation of the tribe eight years later. Subsequently Manuelito was made head of the native police force and proved loyal to the Government.

Manuelito, N. Mex.
Elevation 6,260 feet.
Population 75.*
Kansas City 1,095 miles.

Two-tenths of a mile beyond milepost 179 the State line is crossed and Arizona is entered. The State line is on the thirty-second meridian west of Washington (about 3 miles west of longitude 109° west of Greenwich) and was so defined by law at a time when the

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[1] The first wells at Gallup were not very deep and obtained only a moderate volume of water, but on the advice of a geologist of the United States Geological Survey deeper borings were made with great success. Several other wells have been sunk at places on this railway on similar advice and important water supplies obtained. The study of the conditions under which waters occur underground is a branch of geologic investigation requiring the determination of the succession and structure of the water-bearing rocks and their associated beds.

GEOLOGIC AND TOPOGRAPHIC MAP

OF THE

SANTA FE ROUTE

From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

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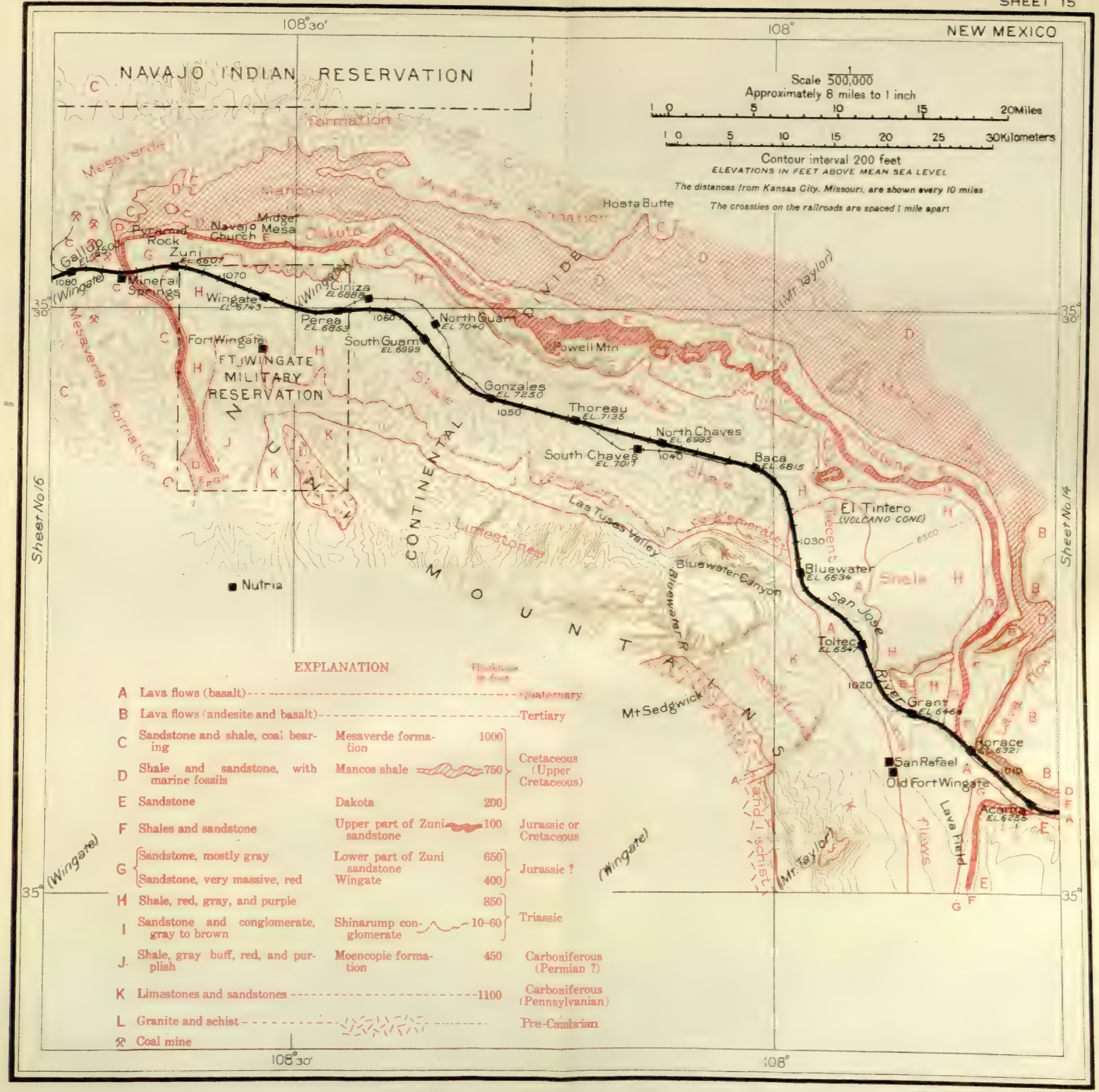
NEW MEXICO
108°30'
108°
35°30'
35°
Scale 1/500,000
Approximately 8 miles to 1 inch
0 5 10 15 20 Miles
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Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart
NAVAJO INDIAN RESERVATION
FT. WINGATE MILITARY RESERVATION
CONTINENTAL DIVIDE
ZUNI MOUNTAINS
Gallup
Pyramid Rock
Navajo Church
Midget Mesa
Zuni EL 6607
Mineral Springs
Wingate EL 6743
Ciniza EL 6888
Perea EL 6853
North Guam EL 7040
South Guam EL 6999
Fort Wingate
Gonzales EL 7250
Thoreau EL 7135
North Chaves EL 6995
South Chaves EL 7017
Baca EL 6815
Hosta Butte
Powell Mtn
El Tintero (VOLCANO CONE)
Bluewater EL 6634
Bluewater Canyon
Bluewater R.
Las Tusas Valley
San Jose River
Toltec EL 6547
Grants EL 6460
Horace EL 6321
San Rafael
Old Fort Wingate
Acoma EL 6258
Mt Sedgwick
Nutria
(Mt. Taylor)
(Wingate)
Lava Field
Mesaverde formation
Mancos
Dakota
Shale
Limestones
Granite and schist
Sheet No. 16
Sheet No. 14
EXPLANATION
A Lava flows (basalt) — Quaternary
B Lava flows (andesite and basalt) — Tertiary
C Sandstone and shale, coal bearing — Mesaverde formation — 1000 — Cretaceous (Upper Cretaceous)
D Shale and sandstone, with marine fossils — Mancos shale — 750
E Sandstone — Dakota — 200
F Shales and sandstone — Upper part of Zuni sandstone — 100 — Jurassic or Cretaceous
G Sandstone, mostly gray — Lower part of Zuni sandstone — 650 — Jurassic ?
G Sandstone, very massive, red — Wingate — 400
H Shale, red, gray, and purple — 850 — Triassic
I Sandstone and conglomerate, gray to brown — Shinarump conglomerate — 10-60
J Shale, gray buff, red, and purplish — Moencopie formation — 450 — Carboniferous (Permian ?)
K Limestones and sandstones — 1100 — Carboniferous (Pennsylvanian)
L Granite and schist — Pre-Cambrian
⚒ Coal mine

Government was attempting to establish an initial meridian passing through the old Naval Observatory at the National Capital. At this place the canyon walls show very massive gray sandstone with numerous shallow caves, alcoves, and buttresses, capped by dark-gray sandstones (probably Dakota).

Arizona.

The area of Arizona is 112,956 square miles. It comprises wide plateaus, in large part from 5,000 to 8,000 feet in height, numerous ridges and mountains, and many wide desert valleys. On account of its great variation in altitudes and its great width from north to south, the State presents a wide diversity of climate, from that of the hot regions near Fort Yuma to that of the cold forested mountains and high plateaus.

Arizona leads in copper production in the United States, the output in 1913 being valued at $63,228,127, or about 90 per cent of the total mineral production of the State. Gold was produced to the value of $4,023,911, and silver, which is mostly a by-product obtained in reducing copper ore, amounted to $2,384,647.

Although the agricultural possibilities of the State are not developed to their full extent, the cultivated hay crop approached a value of $4,000,000 in 1914 and wheat $1,085,000. Wool yielded about $939,000. Range cattle growing is a large industry. Fruit of citrus and deciduous trees, cotton, and corn are being more and more cultivated as new lands are brought under irrigation.

The word Arizona is taken from the Papago language, in which it is said to signify place of small springs. With a population of 204,354, according to the census of 1910, or 1.8 persons to the square mile, it is one of the more thinly populated of our Western States, though less so than Wyoming and Nevada. The ratio of males to females is 138.2 to 100. Of its 72,000,000 acres only 5,000,000 are privately owned, the remainder being public land, Indian reservations, or national forests. Originally Arizona was part of New Mexico, and it continued as such under United States dominion until 1863, when it was made a separate Territory and formally organized at Navajo Springs. Later the capital was at Fort Whipple, Prescott, Tucson, again at Prescott, and finally at Phoenix.

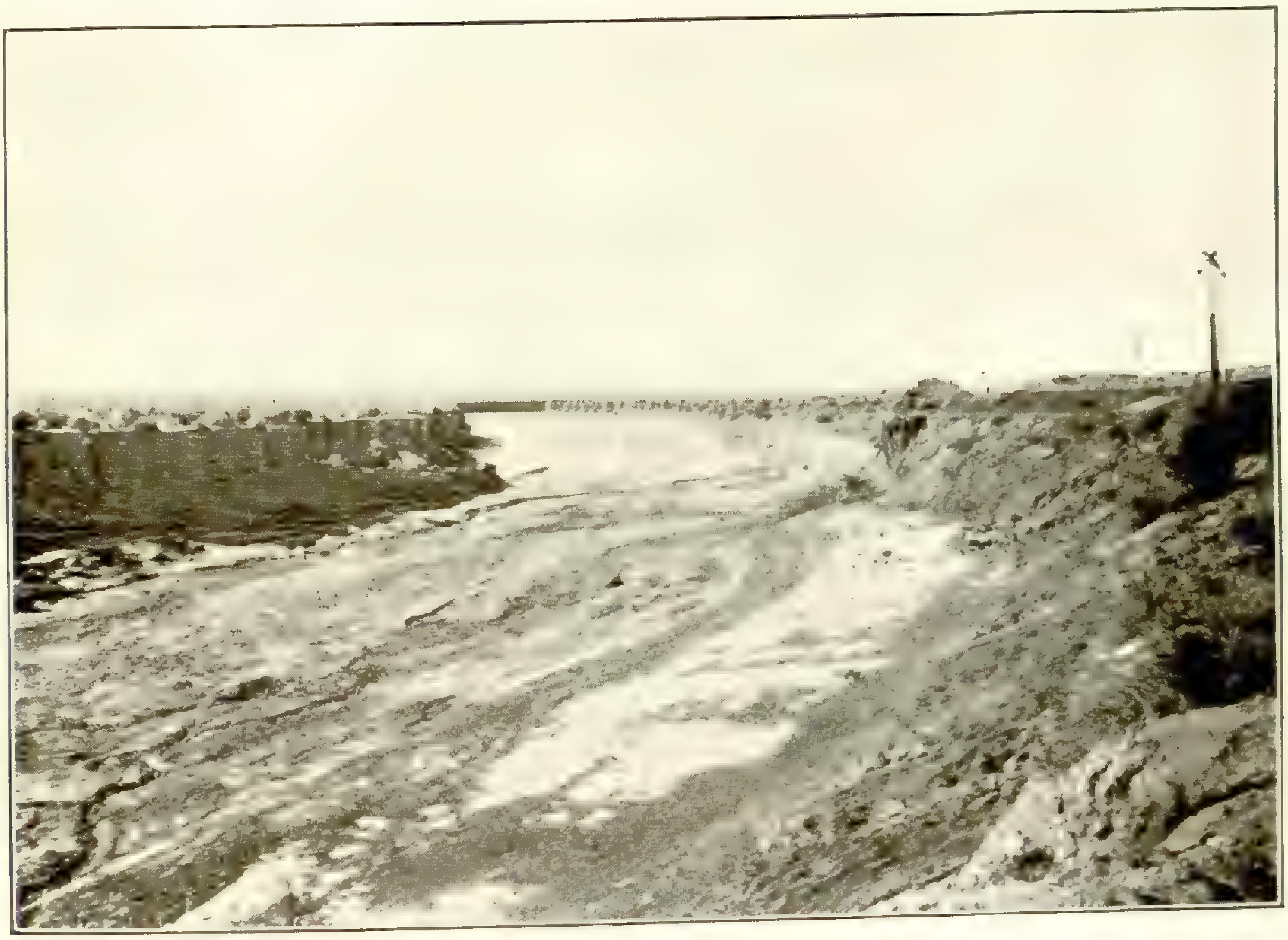
The settlement of Arizona has progressed slowly, and up to 1886 the murderous disposition of the Apache Indians greatly retarded its development. Mainly for this reason there were no white inhabitants in the large area north of Gila River prior to the treaty of 1848. From 1853 to 1857 several governmental surveys were made across the region, mainly to find routes for railways. Most of the earliest visitors were prospectors, and from 1847 to 1860 many mines were opened under more or less protection by the Government. The withdrawal of troops for the Civil War gave the Apaches opportunity to resume depredations, and about 1,000 settlers were killed. Most of the mining operations were discontinued, and the few white people who remained fortified themselves in Tucson, which was taken by the Confederates and held until Union troops came from California. After the war also there was much bloodshed by Indians, who killed about 400 settlers. Gen. Crook subdued the Apaches in 1873 and concentrated them in a reservation, but there were many serious outbursts later under Victorio and Geronimo, with numerous massacres. Victorio was killed in an engagement in 1863, but it was not until 1886 that Gen. Miles forced Geronimo to surrender, and then the Apaches were removed to other States. The Indians were difficult to fight, for they avoided open engagements and could travel fast and far on their ponies.

The Southern Pacific Railroad was built through Arizona in 1880, and the Atlantic & Pacific (now a part of the Santa Fe system) in 1883.

The history of the aborigines in Arizona is extensive, for on plains, on mesas, and in the cliffs there are many ruins of places occupied by the early people. Some of these ruins must be very old. However, it is believed that the number of people living in the region at any time may not have been great, for the aborigines frequently moved from place to place. The early expeditions of the Spanish explorers found many pueblos. The first Spaniard to enter Arizona was Marcos de Niza, a Franciscan friar who crossed its southwest corner in 1539. A year later Niza led Coronado to the Pueblo country, and two small expeditions from this great exploring party visited the Hopi country. The present Indian population of the State is nearly 42,000.

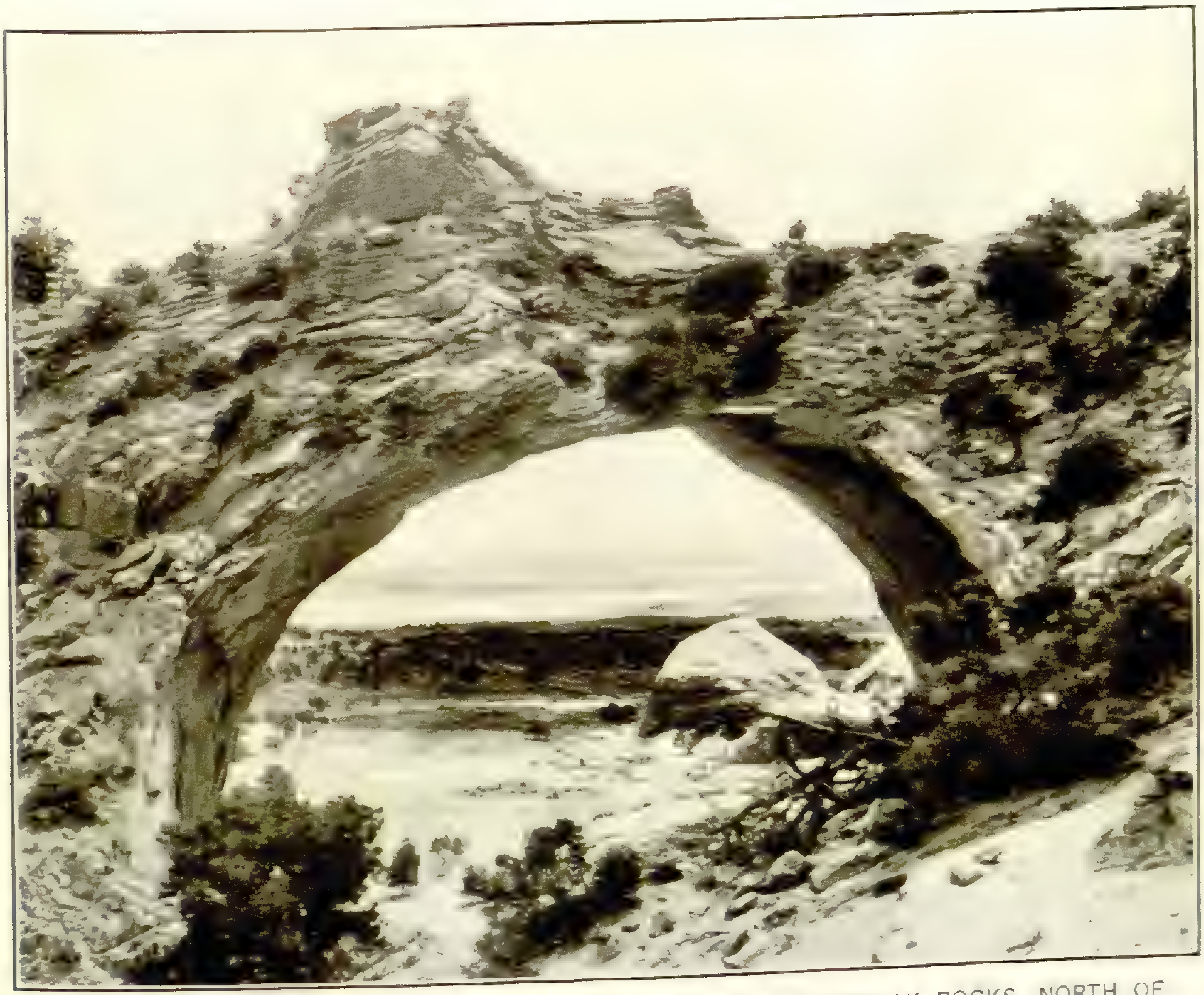
Lupton, Ariz.
Elevation 6,165 feet.
Kansas City 1,101 miles.

About a mile west of Lupton the Zuni and Wingate sandstones, which passed underground 3 miles east of Gallup, rise rapidly in succession, especially to the north of the railway, where the dips are steep for some distance. (See Pl. XIX, *B*, p. 103.) South of Lupton and extending to a point south of milepost 181 there are high cliffs of white to pink sandstones (the Zuni and Wingate) showing many remarkable pinnacles, buttresses, caves, and other features characteristic of erosion in soft, massive rock. They have been eroded by the rain, and especially by wind-blown sand, which cuts rapidly into rocks of this character. One of the most notable arches in these rocks is shown in Plate XX, *B*. It is some distance north of the railway. Beyond the cliffs west of Lupton the rise of the beds to the west brings up the thick succession of shales which lie beneath this sandstone. West of milepost 182 the dips are very low, so that the same rocks continue on both sides of the railway for a



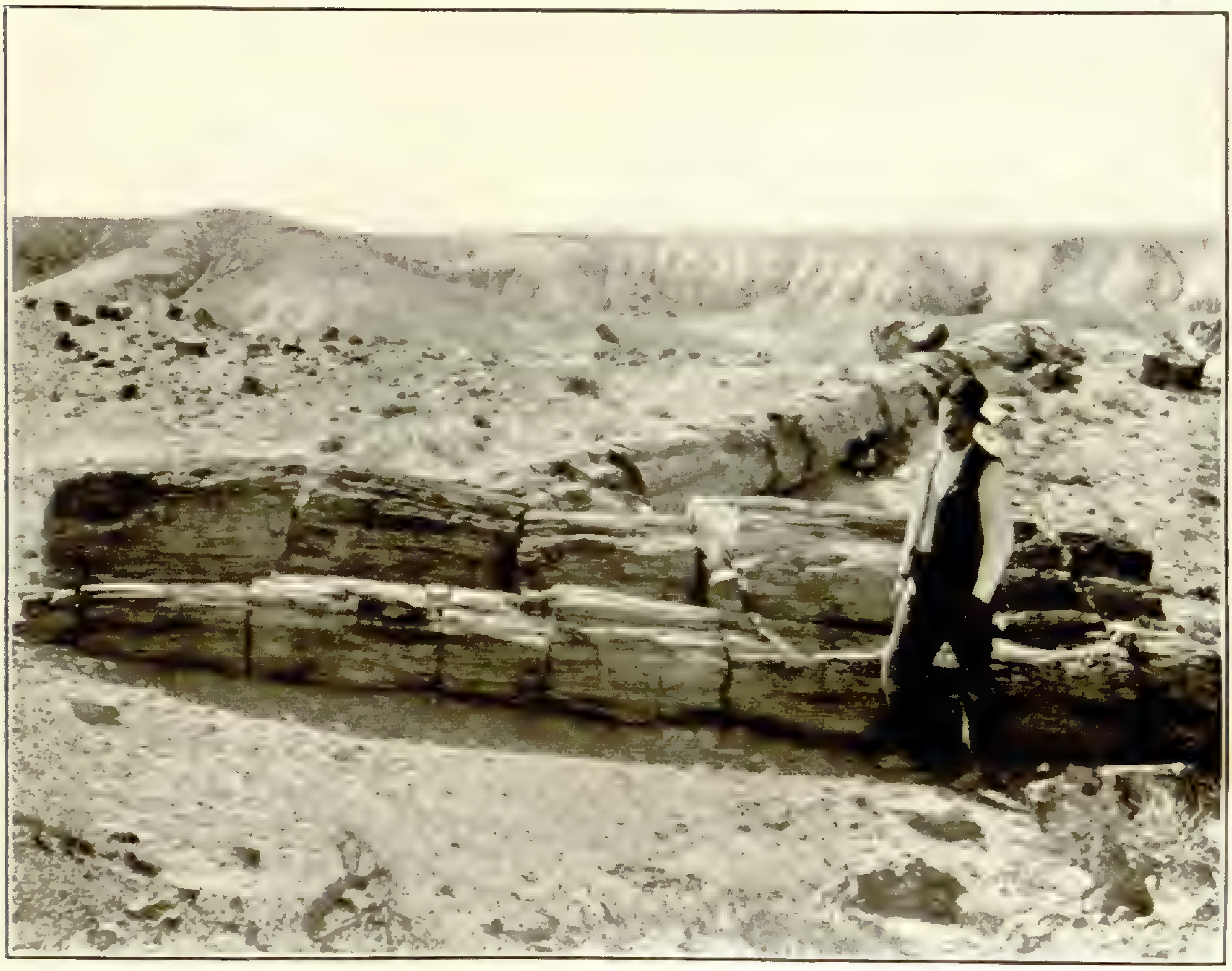
A. BED OF RIO PUERCO AT NAVAJO SIDING, ARIZ.

View southwestward. A typical arid-land arroyo, which is filled to the brim with a swiftly flowing torrent after a rain but soon becomes dry again.

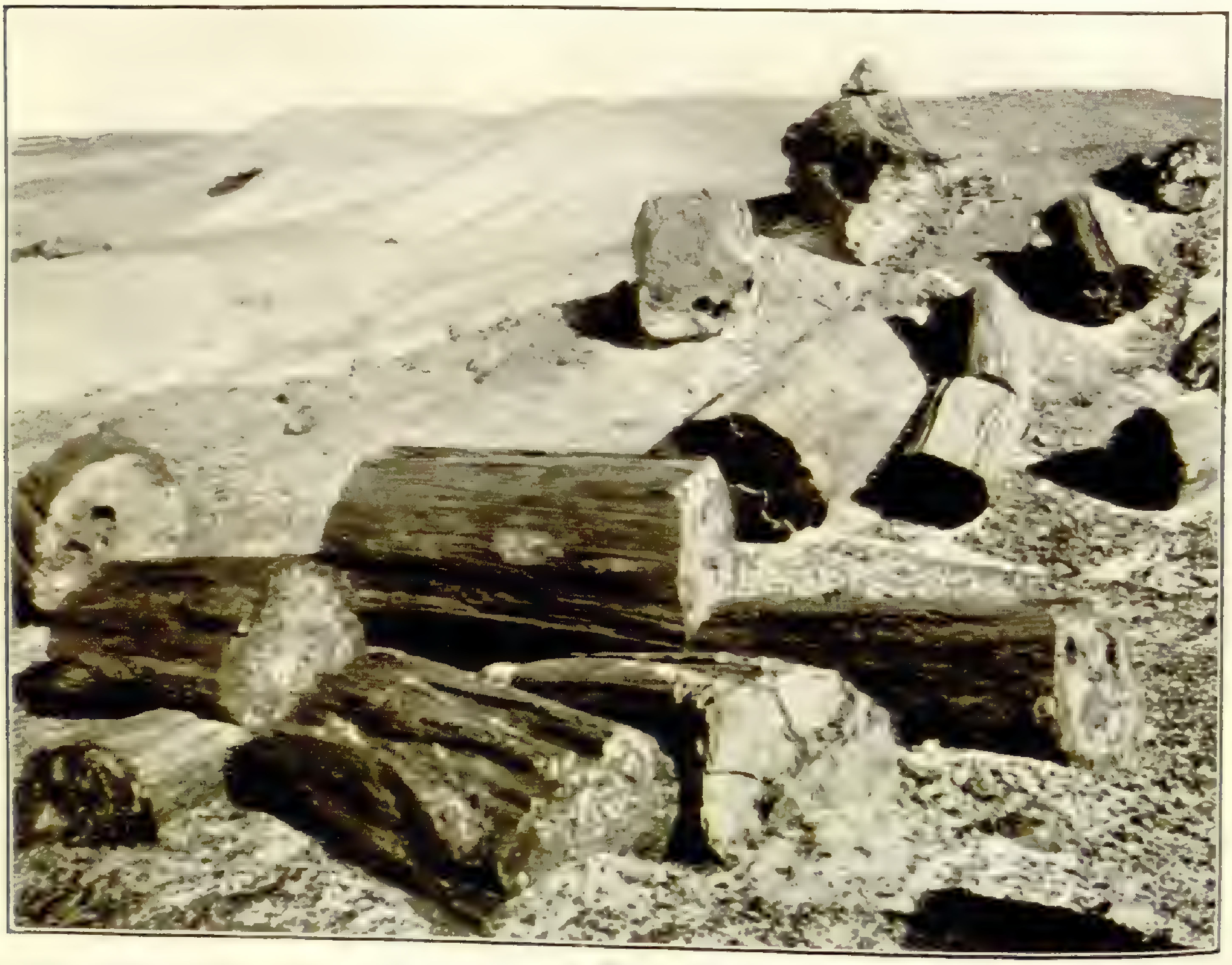


B. NATURAL BRIDGE IN MASSIVE SANDSTONE NEAR THE HAYSTACK ROCKS, NORTH OF MANUELITO, ARIZ.

Shows the work of a small stream which enlarged a crack along a joint plane.



A.



B.

PETRIFIED LOGS SOUTH OF ADAMANA, ARIZ.

The logs were buried in the clays shown in the views.

considerable distance. They are gray and purple shales with layers of gray sandstone, some of which are sufficiently thick and hard to form low mesas that rise at intervals far to the north and south.

Houck.
Elevation 5,965 feet.
Kansas City 1,113 miles.

A short distance west of Houck siding the train enters a canyon about 2 miles long, the walls of which consist of the hard, coarse sandstone that underlies the shales exposed to the east. This rock is regarded as the eastward continuation of the Shinarump conglomerate, which is conspicuous in the country to the northwest. The dip to the west carries this sandstone below the surface west of the canyon, and rolling hills of red shales with gray sandstone layers continue westward to Winslow and beyond. These rocks are exposed here and there in shallow cuts along the railway and in the slopes of the adjoining hills and low mesas. They lie nearly flat.

A 303-foot well at Chambers affords a supply of water rising within 60 feet of the surface.

Navajo.
Elevation 5,633 feet.
Kansas City 1,134 miles.

The first Territorial capital of Arizona was near Navajo, and there has been an Indian trading post there since 1863. Jacobs Well, an important water hole, is not far south. Near milepost 218 the train passes through a shallow canyon in red shale which is capped by a thin deposit of gray sandstone. These beds have a scarcely perceptible dip and constitute the surface along the slopes of the Rio Puerco valley past Pinta siding and Adamana, with remarkable uniformity over a wide area. The Rio Puerco in this region has a bed of considerable width and high banks, but most of the time it is dry or nearly so, as shown in Plate XX, *A*.

Adamana.
Elevation 5,299 feet.
Kansas City 1,154 miles.

The "Petrified Forest," or series of petrified forests, lies a short distance south of Adamana, and the trip to it is made from that station. A small hotel provides accommodations for travelers. The distance to the farthest point usually visited is 9 miles, and this tour can be made in a day or less. In the region south of Adamana there are four "forests," the first 6 miles out, the second 8½ miles, the third 13 miles, and the fourth, the "Rainbow Forest," about 2 miles northwest of the third. They are included in a Government reservation called "Petrified Forest National Monument," created by President Roosevelt in 1906 and placed in charge of the Secretary of Agriculture. The name "forest" is not appropriate, for the petrified tree trunks are all prostrate and are broken into sections. (See Pl. XXI.) The logs are the remains of trees that grew in Triassic time. The trees were of several kinds, most of them being related to the Norfolk Island pine (*Araucaria excelsa*), now used for indoor decoration. These gigantic fossil trees are of later date than those represented by the cones and twigs in the beds at Glorieta Pass, and, as might be expected, they resemble the living Araucarias more closely. They are probably the Triassic descendants of the Permian progenitors of the araucarian family. Doubtless they grew in a near-by region and, after falling, drifted down a watercourse and lodged in some eddy or a sand bank. Later they were buried by sand and clay, finally to a depth of several thousand feet. The conversion to stone was effected by gradual replacement of the woody material by silica in the form called chalcedony, deposited by underground water. A small amount of iron oxides deposited at the same time has given the beautiful brown, yellow, and red tints which appear in much of the material.

All the "forests" present objects of interest, but a visit to the first and second illustrates most of the features. In places the logs are scattered over the surface in large numbers. They vary in size and in length of the trunk sections; in most places the sections are in no regular order, but some of them lie in line very nearly in their original positions. In the first forest they are all out of place, having either rolled down from their original positions in a sandstone layer at a higher level, or been left on the ground as the clay or sand that once inclosed them was washed away. In the second and third forests the original log-bearing stratum may be seen, with many logs only partly uncovered by erosion. Some of the tree trunks are 6 feet in diameter and more than 100 feet in length, but most of them are about half these dimensions. In the first forest there is a fine trunk that forms a natural bridge over a small ravine, the water having first washed away the overlying clay and sand and then, following a crevice, worked out the channel underneath. The length of this log is 110 feet, diameter 4 feet at butt and 1½ feet at top. (See Pl. XXI, *A*.)

The petrified woods are beautiful objects for study. When thin slices are carefully ground down to a thickness of 0.003 inch or less and placed under the microscope they show perfectly the original wood structure, all the cells being distinct, though now they are replaced by chalcedony. By studying the sections, F. H. Knowlton has found that most of these araucarian trees were of the species *Araucarioxylon arizonicum*, a tree now extinct. It is known to have lived at the same geologic time also in the east-central part of the United States, where the remains of some of its associates have also been found. These included other cone-bearing trees, tree ferns, cycads, and gigantic horsetails, which indicate that, at that time, the rainfall was abundant.

The entire area of the "forests" is included in the Government reservation, and visitors are prohibited from carrying away any of the petrified wood or damaging the logs in any way. Petrified wood occurs in many other places in these same beds to the north and south, notably in an area 6 miles north of Adamana or 5 miles north of Aztec

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UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist R. B. Marshall, Chief Geographer
1915

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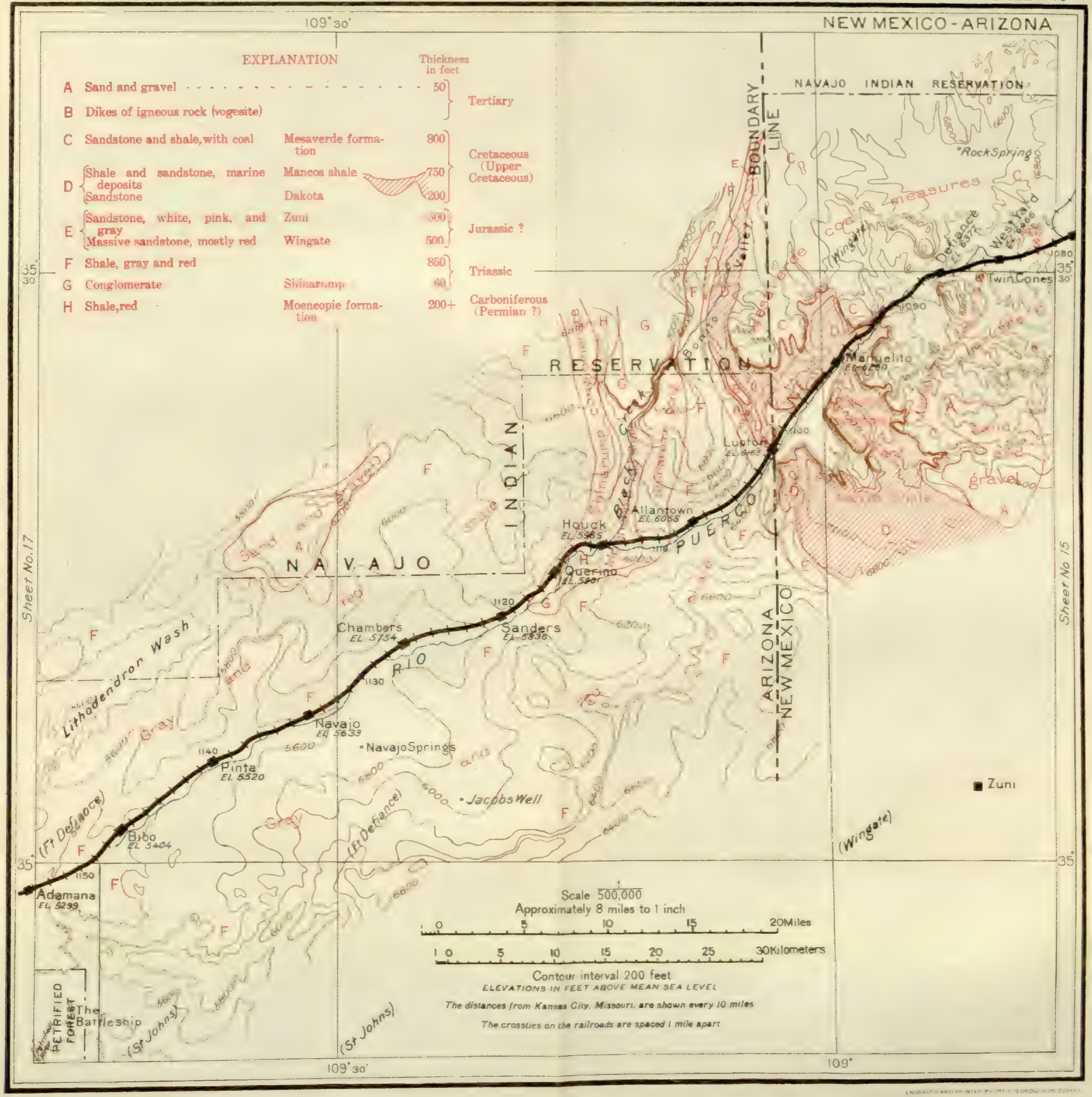
NEW MEXICO-ARIZONA
EXPLANATION
Thickness in feet
A Sand and gravel 50
B Dikes of igneous rock (vogesite)
Tertiary
C Sandstone and shale, with coal Mesaverde formation 800
D Shale and sandstone, marine deposits Mancos shale 750
Sandstone Dakota 200
Cretaceous (Upper Cretaceous)
E Sandstone, white, pink, and gray Zuni 500
Massive sandstone, mostly red Wingate 500
Jurassic ?
F Shale, gray and red 850
G Conglomerate Shinarump 60
Triassic
H Shale, red Moencopie formation 200+
Carboniferous (Permian ?)
109°30'
109°
35°30'
35°
Sheet No. 17
Sheet No 15
NAVAJO INDIAN RESERVATION
NAVAJO INDIAN RESERVATION
BOUNDARY LINE
ARIZONA
NEW MEXICO
Rock Spring
coal measures
Defiance EL 6371
Westland
Twin Cones
Manuelito EL 6240
Lupton EL 6165
Allantown EL 6055
Houck EL 5965
Querino EL 5801
Sanders EL 5838
Chambers EL 5754
Navajo EL 5633
Navajo Springs
Jacobs Well
Pinta EL 5520
Bibo EL 5404
Adamana EL 5299
RIO PUERCO
Lithodendron Wash
Black Creek
Sand
Gray
red
gravel
Zuni
(Ft Defiance)
(Ft Defiance)
(Wingate)
(St Johns)
(St Johns)
PETRIFIED FOREST
The Battleship
Scale 1/500,000
Approximately 8 miles to 1 inch
0 5 10 15 20 Miles
0 5 10 15 20 25 30 Kilometers
Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart

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siding, where there is an interesting "forest," known as the North Forest, of considerable extent. The logs are all in beds not far above the horizon of the Shinarump conglomerate.

A short distance west of the main Petrified Forest, at the head of a small valley which joins the valley of Little Colorado River at Woodruff (see sheet 17, p. 112), is a group of prehistoric pueblo ruins which have been thought to be of Zuñi origin.

A boring was made in the red shale at Adamana to obtain a water supply, but the water, though found with sufficient head to afford a flow, was too salty for use. This condition is almost universal in the red shale of the Moencopie formation, which was penetrated in the boring.

West of Adamana the railway continues down the valley of the Rio Puerco, which widens somewhat because of the softness of the red Moencopie shale, in which it is excavated. The conglomerate (Shinarump) which lies next above this shale, caps slopes and buttes some distance to the north and south.

The beds lie almost flat, so that the railway in descending the valley crosses successively older and lower beds.

Aztec.

Elevation 5,148 feet.
Kansas City 1,167 miles.

A short distance beyond milepost 251 the Rio Puerco empties into Little Colorado River, which flows from the south but turns almost due west after its junction with the Puerco. From this place the railway continues along the north bank of the Little Colorado nearly to Winslow. The valley is wide and contains extensive flats of alluvium, with more or less loose wind-blown sand. In a few places there are ranches where the river water is utilized for irrigation.

Holbrook.

Elevation 5,080 feet.
Population 609.*
Kansas City 1,174 miles.

Holbrook is sustained largely by scattered ranches in the surrounding country. One of the principal industries of the region is the raising of stock, sheep, and goats, and it is reported that 200,000 pounds of wool were shipped from Holbrook in 1914. There is considerable trade with the Indians here, for the Navajo Indian Reservation is only a few miles northeast and the Hopi country begins not far to the northwest. Holbrook is also an outlet for considerable travel coming down the valley of the Little Colorado from St. John and other places farther south.

Holbrook is situated on the red shales and sandstones of the Moencopie formation. The beds dip very gently to the north, and within a few miles in that direction the red rocks pass under the Shinarump conglomerate, the outcrop of which is marked by low cliffs and numerous buttes. The red rocks of the Moencopie formation are prominent all along the valley from Holbrook to Winslow, cropping out in many low cliffs and mesas. A few miles north of the valley are wide areas of badlands, as shown in Plate XXII. These are developed by erosion in the soft sandy clays in the formation overlying the Shinarump conglomerate.

North of Joseph City siding is the Mormon settlement of St. Joseph, where crops are raised by irrigation from the Little Colorado. To the south is an area of 800 acres irrigated from deep wells. These places are conspicuous green oases in a region where the gray desert aspect prevails. Along the Little Colorado Valley at intervals are cottonwood trees, some of them large and clustered in groves of considerable extent.

Manila.
Elevation 4,956 feet.
Kansas City 1,190 miles.

As the Little Colorado Valley widens near Manila and Hardy sidings, there appear to the north many mesas and slender pinnacles of igneous rock which rise high above the general plain. Far to the north in the Navajo Reservation may be discerned the cliff at the edge of an extensive mesa, which contains a large coal field that has not yet been developed.

About 2 miles east of Winslow the railway crosses the Little Colorado, which here makes an abrupt turn to the north. A few miles farther west the river bends to the northwest to join Colorado River in the Grand Canyon at a point about 100 miles northwest of Winslow. The original name of this stream was Rio Lino (that is, Flax River), a distinctive name which would be preferable to the present name.

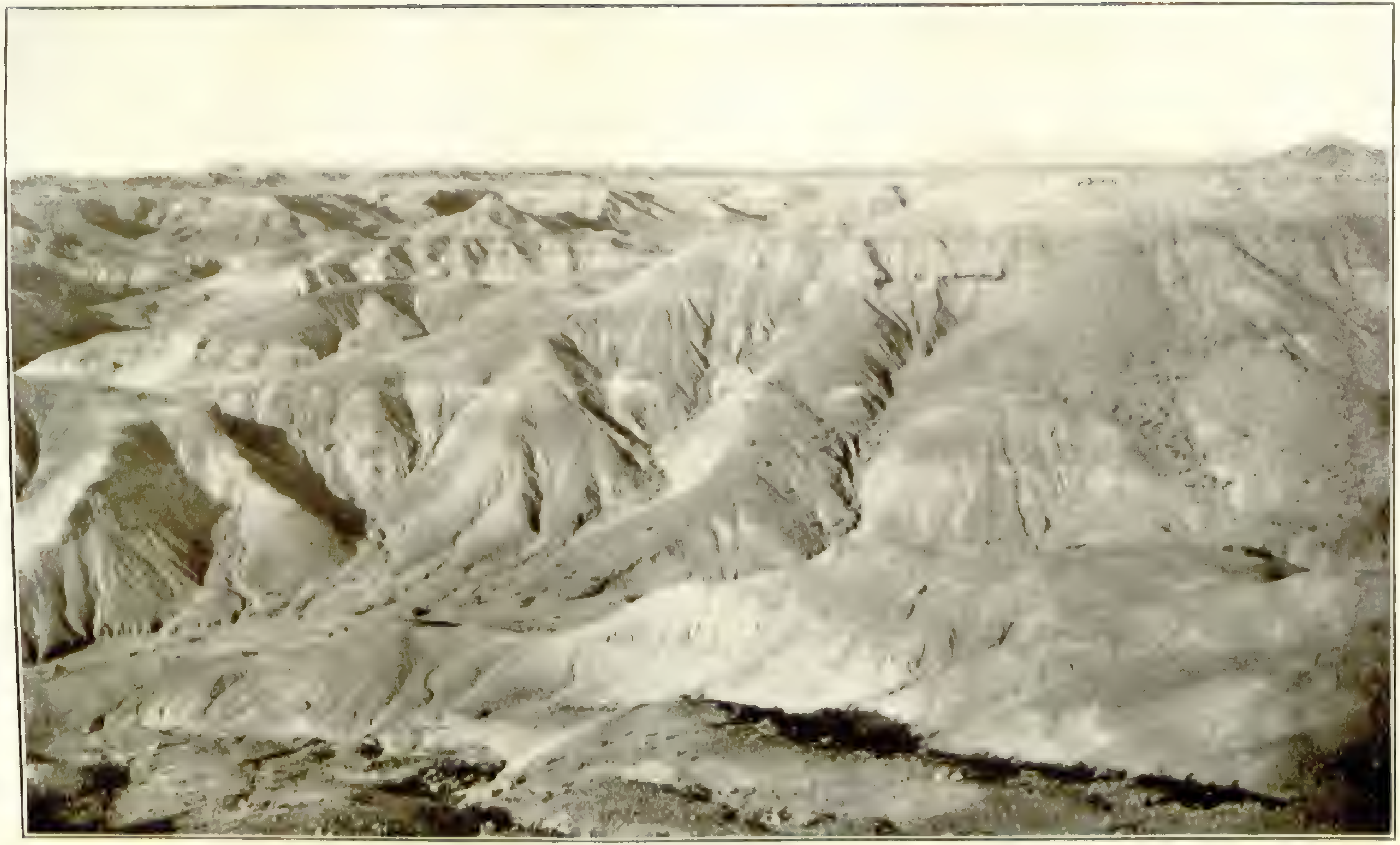
Winslow.
Elevation 4,854 feet.
Population 2,381.
Kansas City 1,207 miles.

Winslow is a railway division point where many trains stop for meals. It is the headquarters for a large surrounding stock country and an important center of trade with Hopi and Navajo Indians (see Pl. XXIII) in the reservations not far north. Near Winslow are the ruins of Homolobi Pueblo, claimed by the Hopis to be the home of their ancestors before the tribe had to flee to the high cliffs far to the north to be safe from their enemies.

Winslow is at the south end of the Painted Desert, a district of undulating plains and bright-colored cliffs, which extends far northward into Utah. The Painted Desert lies between the canyons of Little Colorado and Colorado rivers on the west and the buttes and plateaus of the highlands on the east. Its width in general is about 40 miles, comprising the outcrop of sandstones and shales that are mostly of Triassic age.

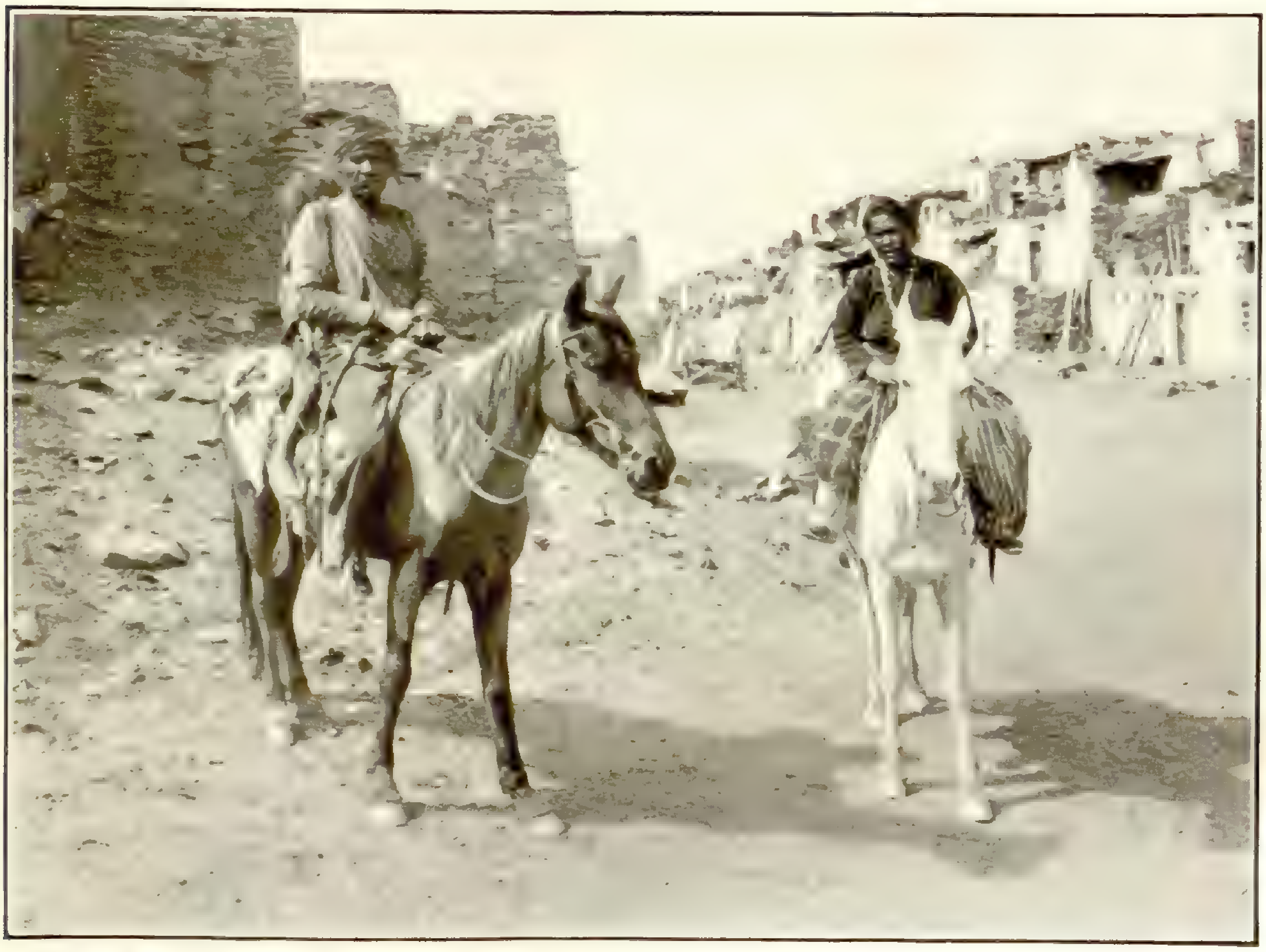
Except in the two rivers there is no running water on the Painted Desert, and springs and water holes are far apart and of small volume.

The Hopi Indian villages of Oraibi (Pl. XXIV), Walpi, Schimopavi, Shipauiluvi, Mishonginivi, Sichomivi, and Hano are picturesquely built on the cliffs which project from a high plateau of sandstone into the western margin of the Painted Desert, about 60 miles north of



BADLANDS NORTH OF HOLBROOK, ARIZ.

View southward. The material is sandy clay. Lava-capped buttes of red sandstone in distance at right.

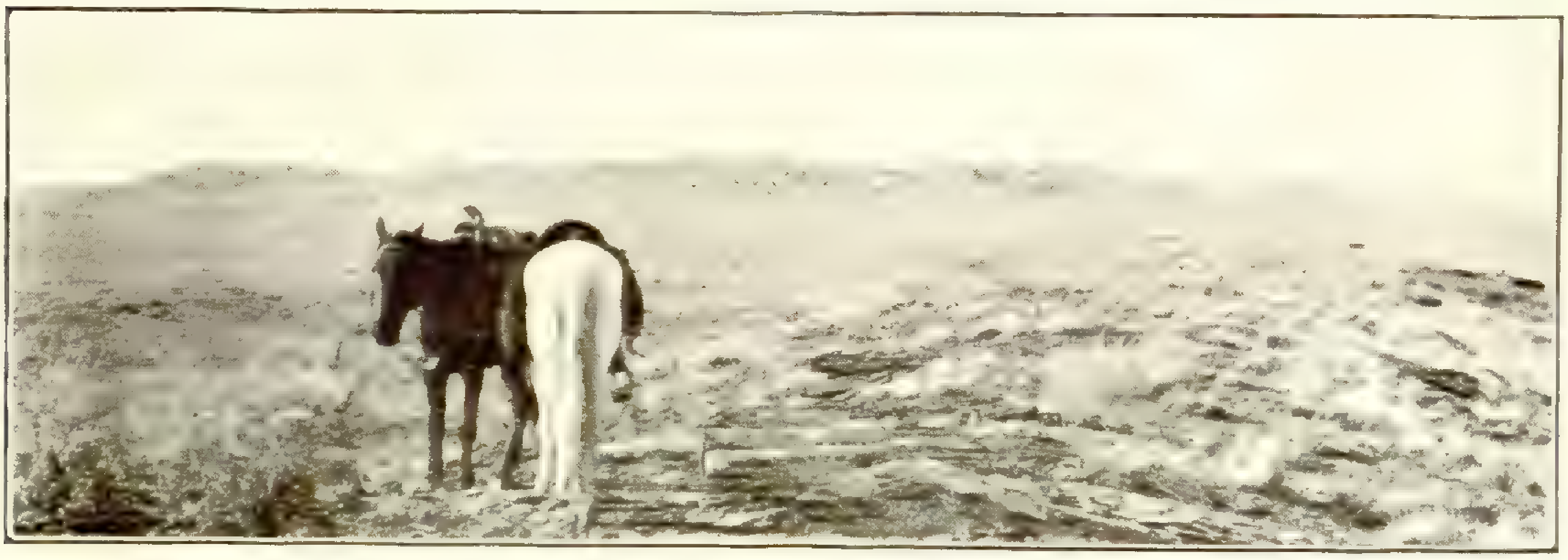


A. NAVAJO INDIANS VISITING THE HOPI INDIANS AT ORAIBI, NORTH OF WINSLOW, ARIZ.

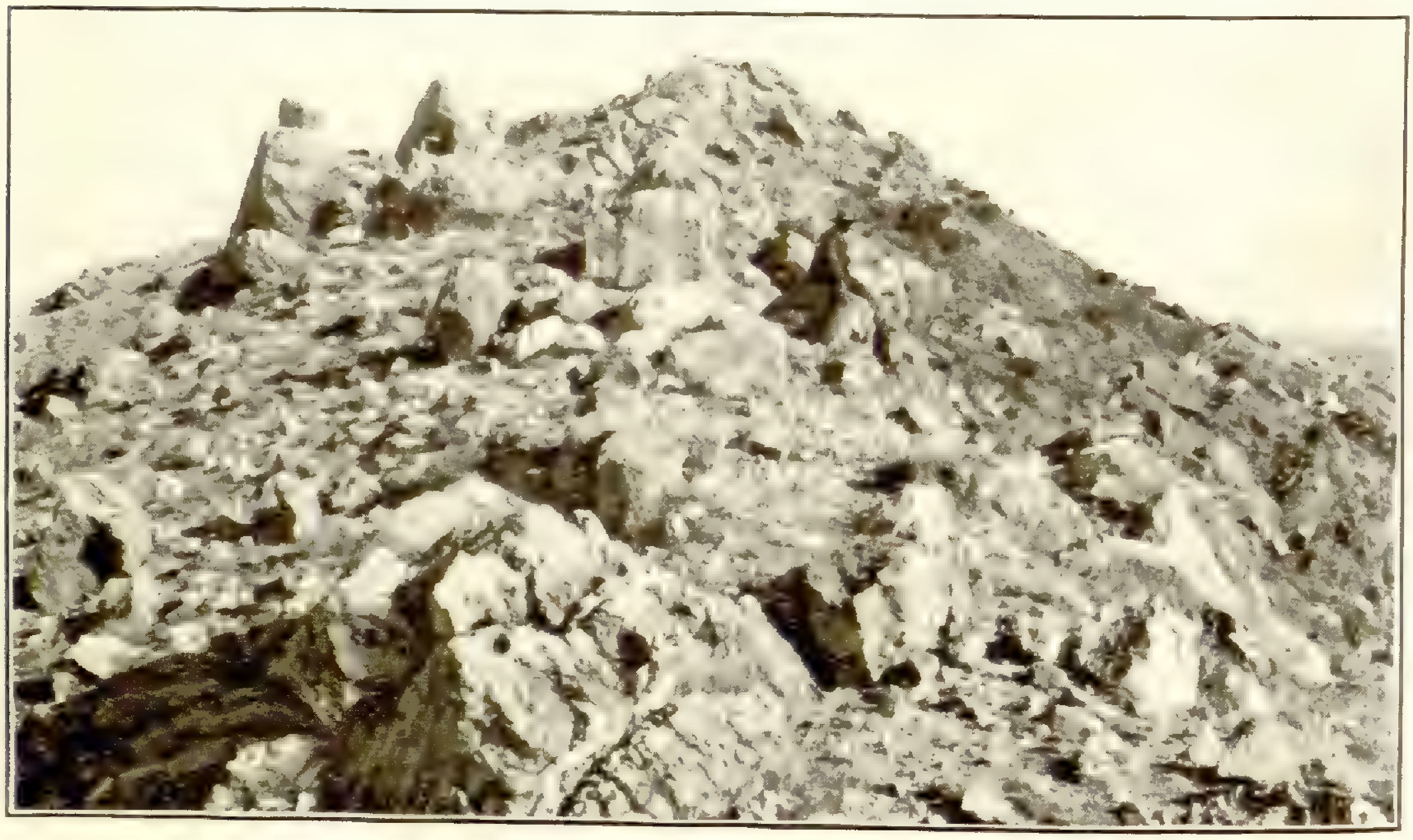
Photograph furnished by Santa Fe Railway Co.

B. AN EVENING WITH NAVAJO INDIANS ABOUT THE CAMP FIRE, NORTH-CENTRAL ARIZONA.

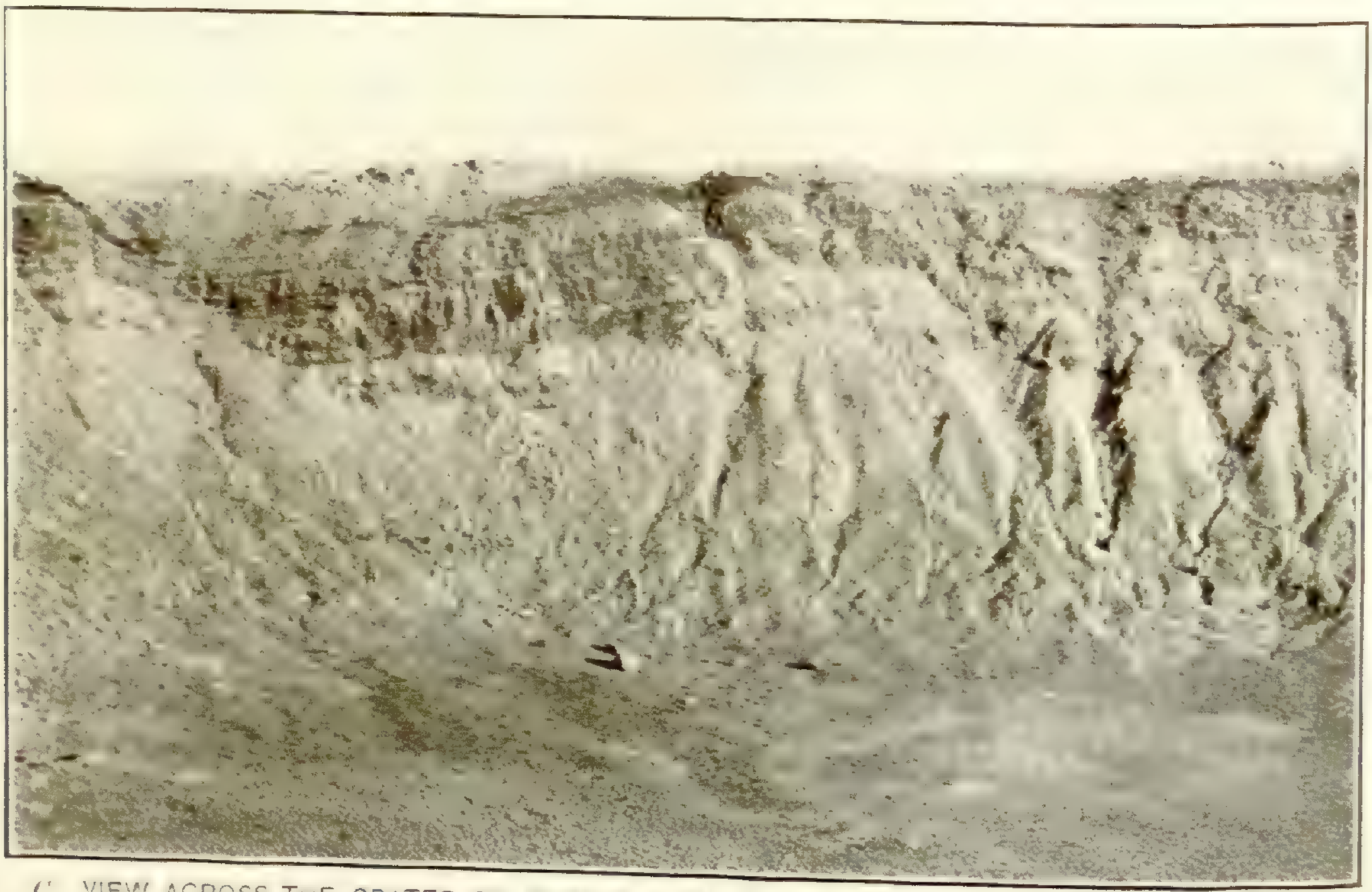
ORAIBI, A HOPI VILLAGE ON THE SANDSTONE PROMONTORIES EAST OF THE PAINTED DESERT, NORTH OF HOLBROOK, ARIZ.



A. VIEW OF CRATER MOUND, ARIZ., FROM THE SOUTHWEST, SHOWING ENCIRCLING RIM.



B. NEAR VIEW OF RIM OF CRATER MOUND.



C. VIEW ACROSS THE CRATER OF CRATER MOUND SHOWING UPTURNED LIMESTONE BEDS IN ITS WALLS.

Winslow. They are in a reservation about 50 by 70 miles in extent which the Government has set aside for the Hopis.[1]

The first white men to visit the Hopi Indians were the members of a party under Pedro de Tovar (toe-vahr′), sent by Coronado. At that time seven villages constituted the province of Tusayan (too-sah′yan), as it was subsequently known. These were in the neighborhood of the present Hopi villages, but the Hopi Indians claim as ancestral homes ruins found as far away as Verde River and the Rio Grande. The present Hopi villages are the objective point of many tourists, especially on the occasion of the far-famed snake dance, which occurs in August.

For centuries the Pueblo people of this arid climate have been developing the Indian maize, a peculiar corn with wonderful drought-resisting properties. It is planted from 6 to 12 inches below the surface, the depth depending on the condition of the soil, and the long single root goes deep to gather the scant moisture of the sandy soil. A stem also extends straight to the surface and there concentrates its energy in seed development, with only a few straggly leaves from its short stalk. Consequently a field of maize presents a very poor appearance compared with an eastern cornfield. However, if there is a little rainfall at the critical part of the growing season, it yields a fair crop.

The climate of this region is typical of much of the higher portions of Arizona, with its scanty rainfall and large percentage of cloudless days (about 60 per cent). The days are dry and hot in summer, but the night temperatures are usually 40° cooler. At Holbrook the mean annual precipitation is 9.16 inches and the mean annual temperature 54.2°. At Winslow the precipitation is 7 inches and the temperature 55°, while Flagstaff, on the plateau 2,000 feet higher, has nearly 24 inches of rainfall and a much lower temperature, 44.7°.

Winslow is on the red sandstones and shales of the Moencopie formation. To the northeast these rocks pass under the Shinarump conglomerate, the outcrop of which extends across the country in low bluffs that may be observed 6 miles northeast of Winslow.

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[1] The name Hopi means "peaceful ones," and the (to them) very unacceptable word Moki, sometimes applied to them by other Indians, is derisive, meaning "dead ones." They are Shoshonean in language, but are a composite of various stocks. They are intelligent, thrifty, tractable, hospitable, and frugal. Their lives are full of toil to raise crops in an arid region, and full of prayers and religious ceremonies largely intended to persuade their gods to send water for the crops. They are monogamists and faithful to marriage ties. Murder is unknown among them, theft rare, and lying deprecated. They now number about 2.100. having diminished considerably in the last 50 years. Escalante reported nearly 7,500 in 1774 and only 798 were recorded in 1780, more than 6.000 having died of disease. A very large proportion of them have trachoma.

Beyond this conglomerate is a wide area occupied by a thick succession of light-colored shales, and in the distance are scattered buttes of still higher red sandstone (the Wingate), capped by small remnants of old lava sheets. Some of these lava buttes are very prominent features in the landscape far to the northeast of Winslow. The Moencopie formation extends northwest of Winslow and Moqui siding in a broad belt down the valley of the Little Colorado, which finally cuts down into the underlying limestone (the Kaibab). West of Winslow the train leaves this valley and climbs gradually to the Arizona Plateau. This extensive table-land rises continuously to Flagstaff and beyond and also northwestward to the edge of the Grand Canyon. The greater part of its surface consists of bare limestone (the Kaibab), which dips at a low but nearly uniform angle to the east and southeast. At Winslow this limestone is some distance beneath the surface, under the red sandstones of the Moencopie formation, but as it rises to the west at a somewhat more rapid rate than the ascent of the railway it finally reaches the surface. It first appears at a point a short distance beyond Dennison siding (see sheet 18, p. 120), but for several miles, to and beyond Sunshine siding, numerous outlying masses of the basal red sandstone of the Moencopie remain on it. Just south of Sunshine this sandstone has been quarried to a considerable extent for building stone.

Sunshine.
Elevation 5,341 feet.
Kansas City 1,227 miles.

About 10 miles south of Sunshine is Crater Mound, long known as Coon Butte and for a while as Meteorite Mountain, perhaps the most mysterious geologic feature in the West. Viewed from the railway, it appears as a low ridge (see Pl. XXV, *A*), but on near approach this ridge is found to be circular and to inclose a great hole 4,000 feet in diameter and 600 feet deep.[1] (See Pl. XXV, *C*.) The encircling ridge is from 100 to 150 feet high and consists of loose fragments

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[1] The cause of this great hole in the ground has not been ascertained. Several geologists believe that it was made by the impact of a great meteor, a view suggested by the occurrence of many small masses of meteoric iron in the vicinity, as well as elsewhere in the surrounding country, but a mining company organized to find and work the large mass supposed to be buried in the hole failed to obtain any evidences of its existence. Many test borings and a shaft were sunk 200 feet into the detritus in the floor of the hole, and a 1,020-foot hole found that the underlying sandstones are not disturbed. Moreover, a detailed survey with a magnetic needle, hung to swing vertically, failed to show any evidence of the presence of a body of metallic iron.

Another suggestion is that the hole is due to an explosion of steam from volcanic sources below, accumulating in the pores of the sandstone and finally reaching the limit of tension. This would account for the broken sandstone and limestone constituting the encircling rim and for the upturned edges of the strata, which doubtless would bend upward somewhat before they broke. The large amount of fine sand produced would result from the violence of the explosion of steam contained in the interstices of the sandstone. Such an explosion might not greatly disturb the underlying Supai sandstone if the

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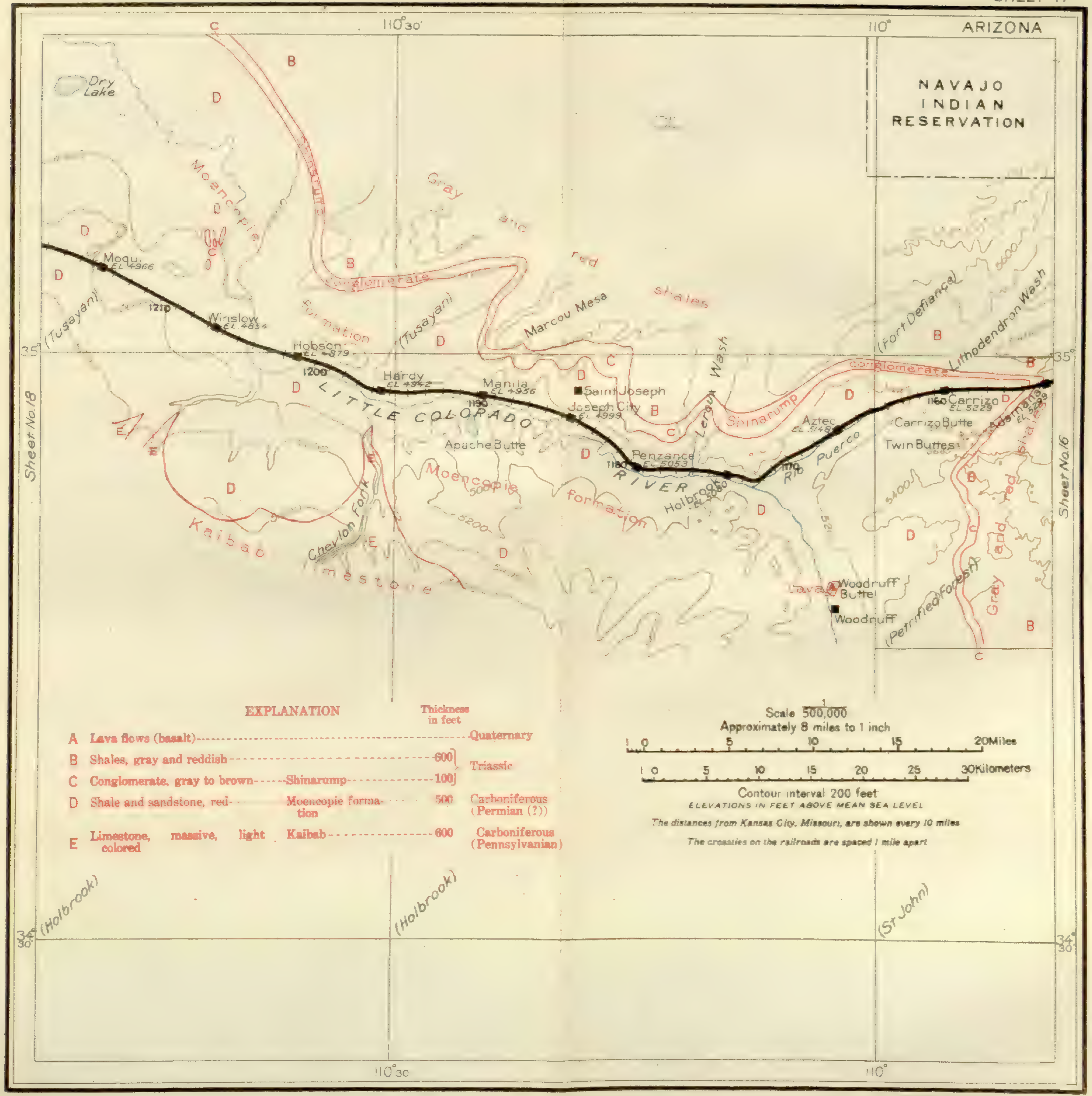

EXPLANATION

			Thickness in feet	
A	Lava flows (basalt)			Quaternary
B	Shales, gray and reddish		600	Triassic
C	Conglomerate, gray to brown	Shinarump	100	
D	Shale and sandstone, red	Moencopie formation	500	Carboniferous (Permian (?))
E	Limestone, massive, light colored	Kaibab	600	Carboniferous (Pennsylvanian)

Scale $\frac{1}{500,000}$
Approximately 8 miles to 1 inch
1 0 5 10 15 20 Miles
1 0 5 10 15 20 25 30 Kilometers
Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart

of rock and sand blown out of the hole. (See Pl. XXV, *B*.) The beds of rock in the walls of the hole are Kaibab limestone at the top and Coconino sandstone below, both more or less upturned near the hole and in part considerably shattered. The relations are shown in figure 23. The best view of Crater Mound is obtained from points near milepost 309.

West of Sunshine there is a nearly continuous exposure of the Kaibab limestone to Flagstaff, and this rock also extends far to the north, south, and southwest. As the slope is ascended northwest of Sunshine siding there is a fine view of the Painted Desert far to the northeast, and beyond it may be seen dimly the high promontories or plateaus on which the Hopi villages are built.

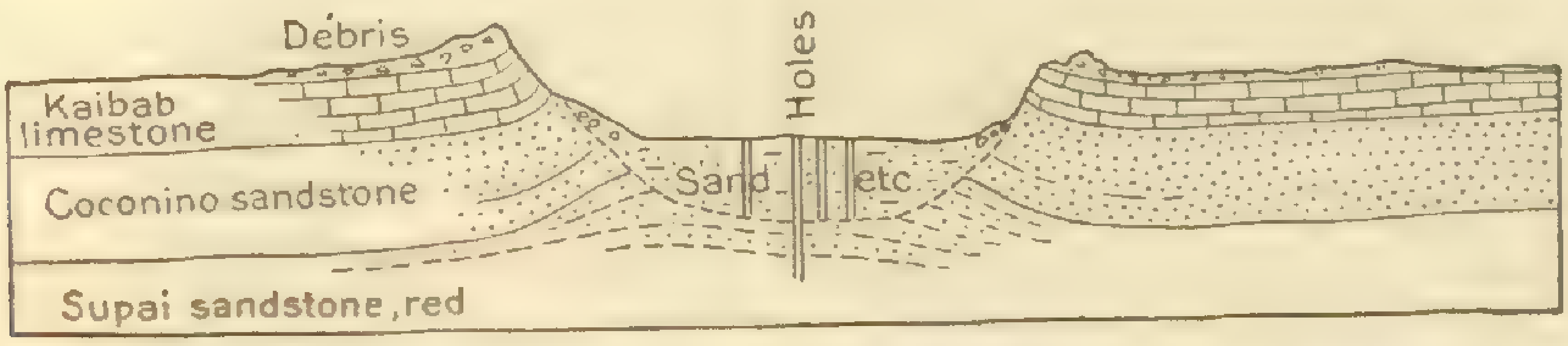

FIGURE 23.—Generalized section across Crater Mound, Ariz.

Canyon Diablo.
Elevation 5,429 feet.
Kansas City 1,233 miles.

A short distance beyond Canyon Diablo station the railroad crosses the canyon on a long steel bridge, affording a very good view of this interesting feature. (See Pl. XXVI.) The canyon is steep walled, about 225 feet deep, 550 feet wide, and entirely in the Kaibab limestone. The beds, which are thick and massive, are nearly horizontal and appear as huge steps descending to the bottom of the canyon.

Just beyond Hibbard siding is another canyon known as Canyon Padre (pah′dray), not as deep as Canyon Diablo, but of similar shape. Both of them are excellent illustrations of the results of erosion in hard limestone by streams of considerable slope. The flow is transient, for only at times of rainfall is there any water in them, but then the current is swift and the water carries much sand, which vigorously cuts away the limestone.

West of Canyon Padre there may be seen ahead and to the north many knobs and ridges rising above the plateau surface. They consist of volcanic rocks which cover a wide area to the northwest

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zone of explosion were in the overlying Coconino sandstone, which is much the more porous material. The locality is in the midst of a region of former great volcanic activity, for although there are no lava flows in the immediate vicinity of the hole there are large outflows and vents not many miles away in all directions. A somewhat similar hole or crater holds the Zuni Salt Lake, 115 miles to the southeast. From its center rise two very recent cinder cones, one with a deep crater in its top. The rim surrounding the big hole consists of a mixture of volcanic ejecta and fragments of rocks from far below the surface.

and culminate in the high peaks of the San Francisco Mountains, 25 miles away, which are prominently in view for many miles along the railway.

At milepost 320 there is a cinder cone a short distance north of the railway, with a lava flow extending from its base to the east and another to the south, the latter reaching nearly to the track. The cone is remarkably symmetrical and fresh looking, and the lava flow is closely similar to that which is exposed near Grant and Horace, 220 miles farther east. A short distance north of the cone is the southern margin of a wide area of lava (basalt), which extends far to the north as well as to the northeast and northwest. On its rugged surface are many cinder cones which are visible more or less distinctly from the train. (See Pl. XXVII.)

Between mileposts 319 and 320 is a signboard reading "Eastern boundary Coconino National Forest." This forest is one of two Government reservations which include the great forest of yellow pine (*Pinus ponderosa*) covering the higher part of the Arizona or Coconino Plateau.[1]

As the limestone plateau is ascended, the first trees observed are stunted junipers and piñons; these rapidly increase in size and abundance as the higher altitudes are attained, a feature especially noticeable between Angell and Winona sidings.

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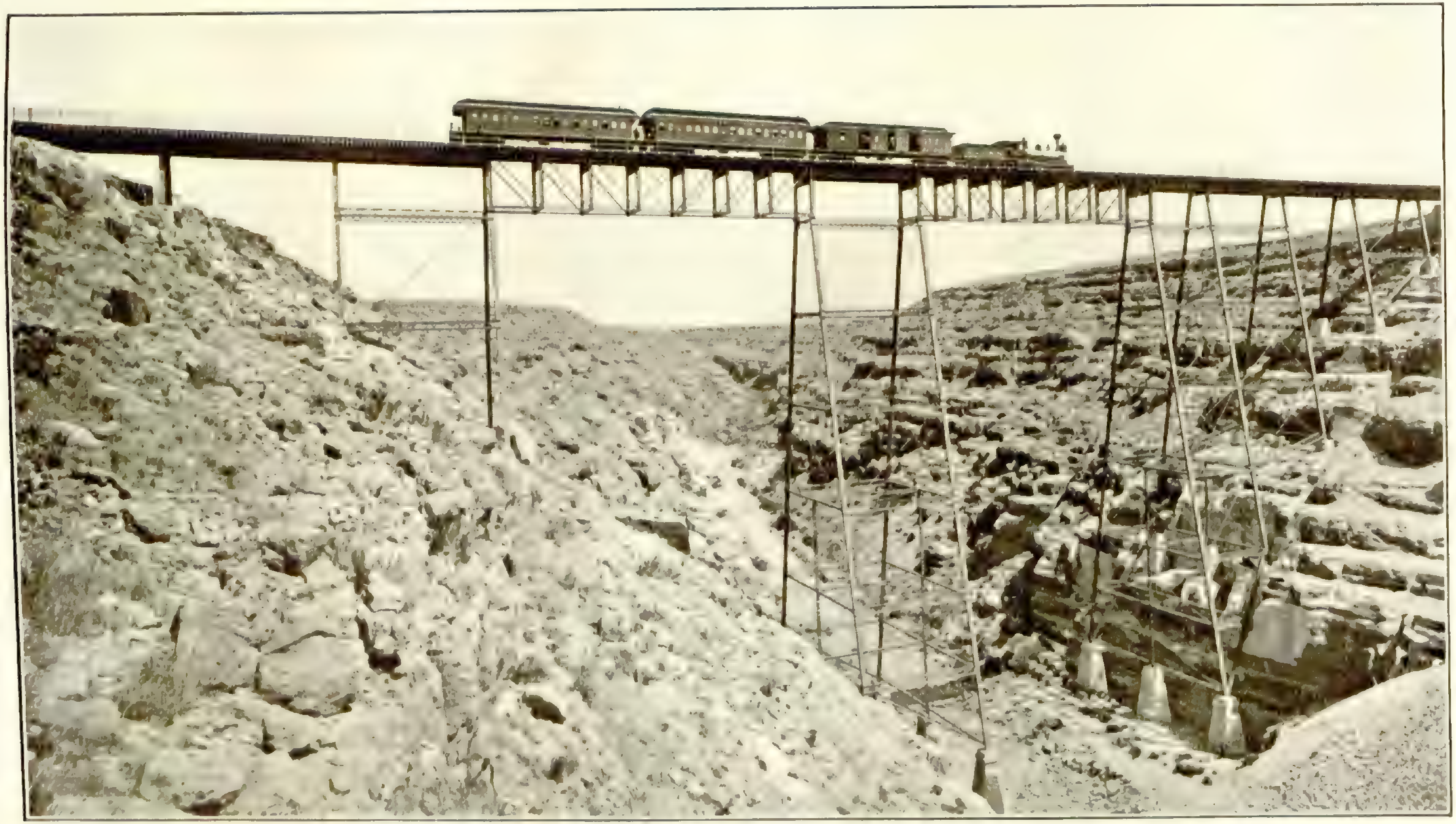
[1] These great forests extend northwestward to the Grand Canyon, westward to and beyond Williams, and southward to the southern margin of the plateau. They include about 1,317,000 acres of western yellow pine. In parts of the forest and in a broad zone around its margin are junipers (*Juniperus occidentalis* var. *monosperma*) and piñons (*Pinus edulis*). The pines grow on the limestone and volcanic rocks, and the forest limits are determined by the moisture, which in turn is largely controlled by the altitude. Accordingly the pine growth is nearly all in the area higher than 6,200 feet, for at lower altitudes than this the precipitation is insufficient; in fact, even in some of the western portions of the high plateau, where the altitude is slightly above this amount, the rainfall is too scanty or the soil too dry to support a forest. The yellow pine gives place to other trees, mainly firs, spruce, and aspen, above 8,500 to 9,000 feet, and the forest ceases at an altitude of 12,000 feet on the San Francisco Mountains.

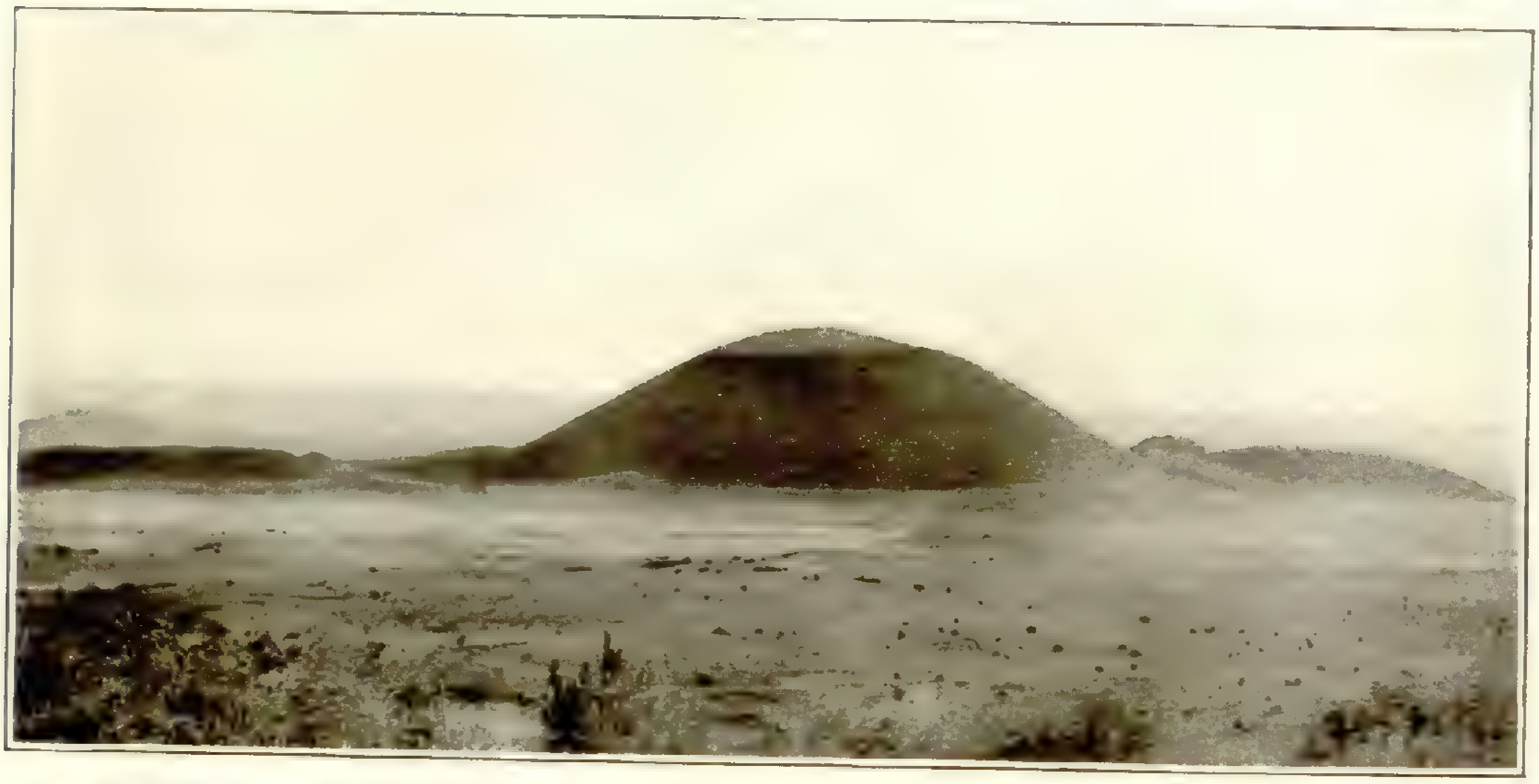
The investigations of the Geological Survey and the Forest Service on the relation of forests to water supply and soil waste indicate that forests in mountainous districts conserve the precipitation for stream flow and increase the underground storage of water. The trees break the violence of the rain, retard snow melting, and increase absorption by the soil, all of which diminish erosion of the surface and rapidity and volume of run-off. Underground seepage is increased, so that a steady flow is maintained in springs and streams, and less silt is removed, hence there is less to obstruct the stream beds.

Fires have ravaged many parts of the forests, and one of the principal functions of the Forest Service is to prevent or extinguish them. Lookouts are maintained on high points. Lightning starts fires and destroys many trees that do not ignite. It has been estimated that 40,000 trees were struck in three years in the high plateau province of Arizona and adjoining regions.



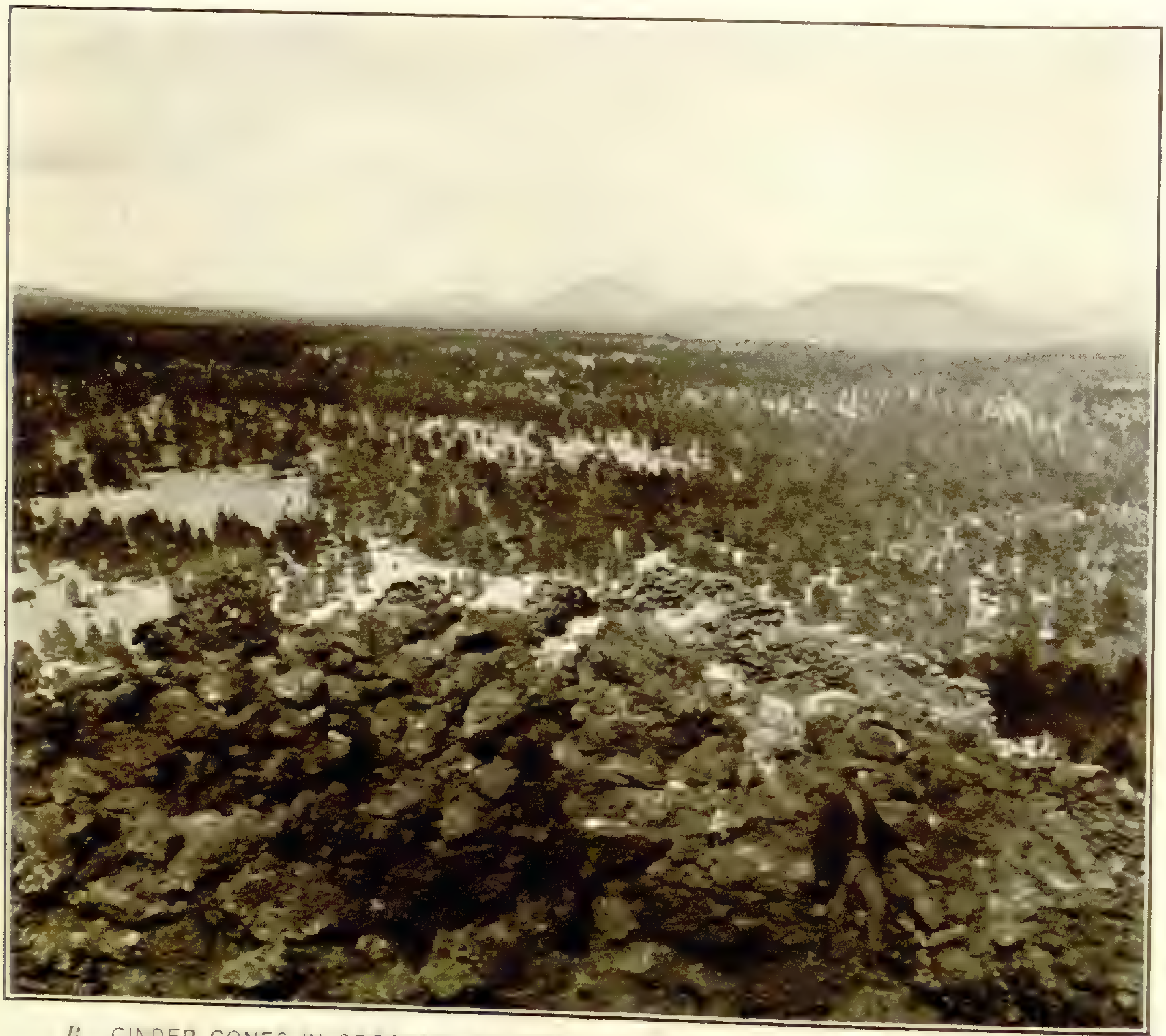
CANYON DIABLO, ARIZ.

View up the canyon at a point between Winslow and Flagstaff. The steplike ledges of Kaibab limestone at the right lie nearly horizontal. Photograph taken thirty years ago. Shows old-time train of Atlantic & Pacific Railroad, the predecessor of the Santa Fe Railway.



A. RECENT CINDER CONE EAST OF SAN FRANCISCO MOUNTAINS, NORTH OF WINONA, ARIZ.

Rises above broad sheets of lava and marks a vent.



B. CINDER CONES IN COCONINO FOREST EAST OF SAN FRANCISCO MOUNTAINS, ARIZ.

View from edge of a recent cone showing large fragments of lava and cinder.

Angell.
Elevation 5,910 feet.
Kansas City 1,243 miles.

At Angell and for several miles west many cinder cones are visible on the widespread lava sheet which begins a short distance north of that siding. Most of these cones are from 150 to 250 feet high. They consist of piles of loose, dark volcanic cinder or pumice which varies from pieces 2 inches in diameter to fine sand. The deposit includes volcanic bombs, rounded masses of more compact lava, which were ejected from volcanic vents. This region of lava occupies an area about 15 miles wide from north to south and 70 miles long from east to west, with the San Francisco Mountains near the center. It has been designated the San Franciscan volcanic field.[1]

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[1] Three general periods of volcanic activity are indicated in this field. First came a widespread outflow of basalt, which issued from numerous cracks in the limestone and underlying strata in a very fluid condition and spread widely over the gently sloping surface of the plateau. In the second period occurred the eruption of several large masses of more viscous lavas (andesite, dacite, and latite) now constituting San Francisco Mountain, Kendrick Peak, Elden Mountain, O'Leary Peak, and other high summits. These lavas, being less fluid than the earlier basalt, piled up and in part arched up on it in high mounds of relatively small extent. As these rocks are hard and massive they give rise to very prominent topographic features. It is probable that there was a considerable interval of time between the first basalt eruptions and the outflows of less fluid lavas, but apparently all of them were extruded late in Tertiary time. There are also bodies of intruded rhyolite which apparently cut across the earlier basalt at several localities, notably in Sitgreaves Peak, Government Mountain, and O'Leary Peak. This rhyolite is a light-gray or nearly white rock, usually breaking into thin slabs.

In the third period of eruption in the San Francisco volcanic field occurred an extensive outflow of black lava (basalt) similar to the first. It came out of numerous cracks and other orifices, mostly within the area of the earlier lava sheets. The lava at many localities ran down valleys which had been eroded in the earlier lava sheets or the underlying limestone in the interval between the periods of eruption. Most of this later lava is exceedingly fresh in appearance, similar to that occupying the San Jose Valley at Grant and McCartys, N. Mex., which is described on pages 97–98.

At many of the vents the cessation of lava flow was followed by an outburst of cinders and ash. This material was thrown up into the air for some distance and, settling back about the vent, formed a cone, as a rule with a central crater. The building of these cinder cones usually marked the last stage of activity of the crater, but in some places a later gush of lava was poured out from the side or base of the cone. The lava contained a vast volume of steam, for much of it is highly porous, owing to the expansion of the steam in the cooling rock as it flowed out over the surface. The cinder consists of lava filled with small steam holes, so that most of it is completely porous or pumaceous. In the cinder cones are usually included masses of compact lava probably thrown out as bombs. These vary in form from perfectly round balls to elongated and irregular shapes such as might be expected in molten material ejected from a vent. Their surface is smooth. In places there are flattened masses of lava several square yards in extent, in part twisted around some of the cinder in which they are inclosed. Several of the cinder cones doubtless date back to the earlier basalt eruption, but most of them appear to belong to the last period.

There are several hundred cinder cones in the field, presenting a great variety in size, height, and stage of preservation. Many have deep craters or hopper-shaped cavities at the top. The distribution of most of them is shown in figure 24, which also shows the approximate extent of the lava fields. Excellent views of cinder cones may be had to the northwest from mileposts 321, 324, and 325, and at Winona there are two small cones a short distance south of the track.

At milepost 326 the railway reaches the south edge of the great basalt flow. It continues along this edge but is built mostly on the underlying limestone almost as far as Flagstaff. There is a cut in the basalt on the north side of the track at milepost 326. At milepost 328, just east of Winona, the railway enters the basalt area, on which it continues for about a mile, and at many points in the next few miles the edge of the basalt is a short distance north of the tracks.

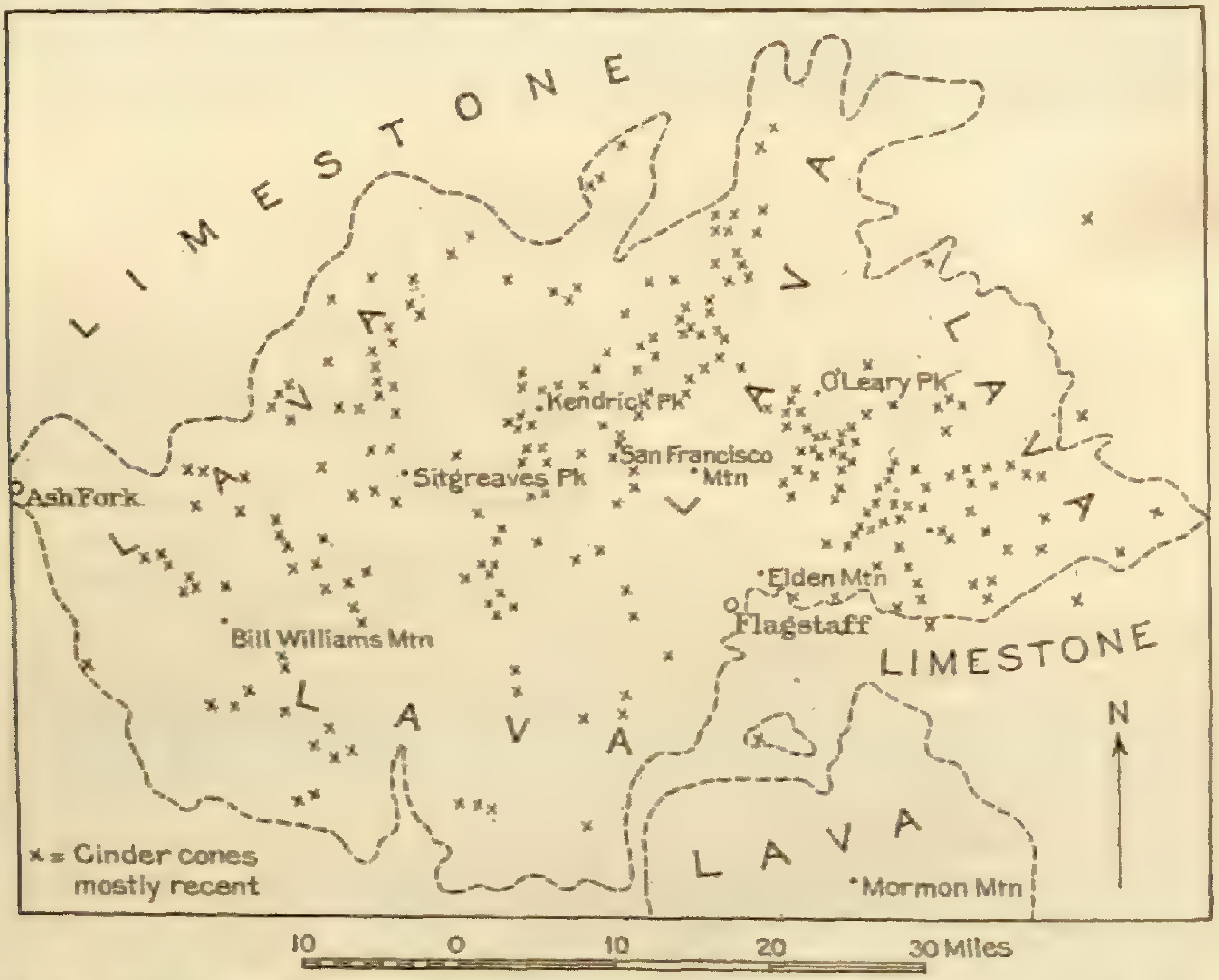


FIGURE 24.—Map of the lava field in the San Francisco Mountain district, Ariz., showing distribution of cinder cones marking vents of eruption. (After H. H. Robinson.)

Between Winona and Cosnino sidings the San Francisco Mountains are in plain sight to the northwest, and many minor volcanic peaks are also visible to the north. In greater part the railroad is built on the Kaibab limestone, which is well exposed in several cuts.

Cosnino.

Elevation 6,466 feet.
Kansas City 1,254 miles.

At Cosnino the pines begin to be numerous and of large size, and a short distance to the west, at an altitude of about 6,300 feet, the traveler enters the great pine forest which extends continuously to Williams. Cosnino is a name formerly applied to the Havasupai tribe of Yuman Indians, who live in Cataract Canyon, near Grand Canyon. They once occupied permanent villages on the Arizona Plateau but were forced to abandon them owing to the hostility of tribes living farther east.

Two miles beyond Cosnino the train approaches a large cinder cone which extends for about a mile along the north side of the track, and halfway between mileposts 336 and 337 there are cuts exposing some features of the cinder deposits constituting this cone. Most of the material is fine grained but there are many included masses consisting of cinder agglomerated together and numerous bombs.

One of the most notable examples of a recent cinder cone is Sunset Peak, which is visible 10 miles to the north from the vicinity of milepost 337. This cone is 300 feet high and has steep slopes of loose cinders, part of which are of a bright-red color, giving the cone the appearance of being illumined by the setting sun. The crater at the top is 80 feet deep and 200 feet in diameter, but the original orifice under this depression is covered by the loose material sliding down the steep slopes.

Halfway between mileposts 338 and 339 is a red cinder cone 200 feet high, half a mile north of the railway, with a small tongue of lava extending from its base southward to a point a short distance east of milepost 339.

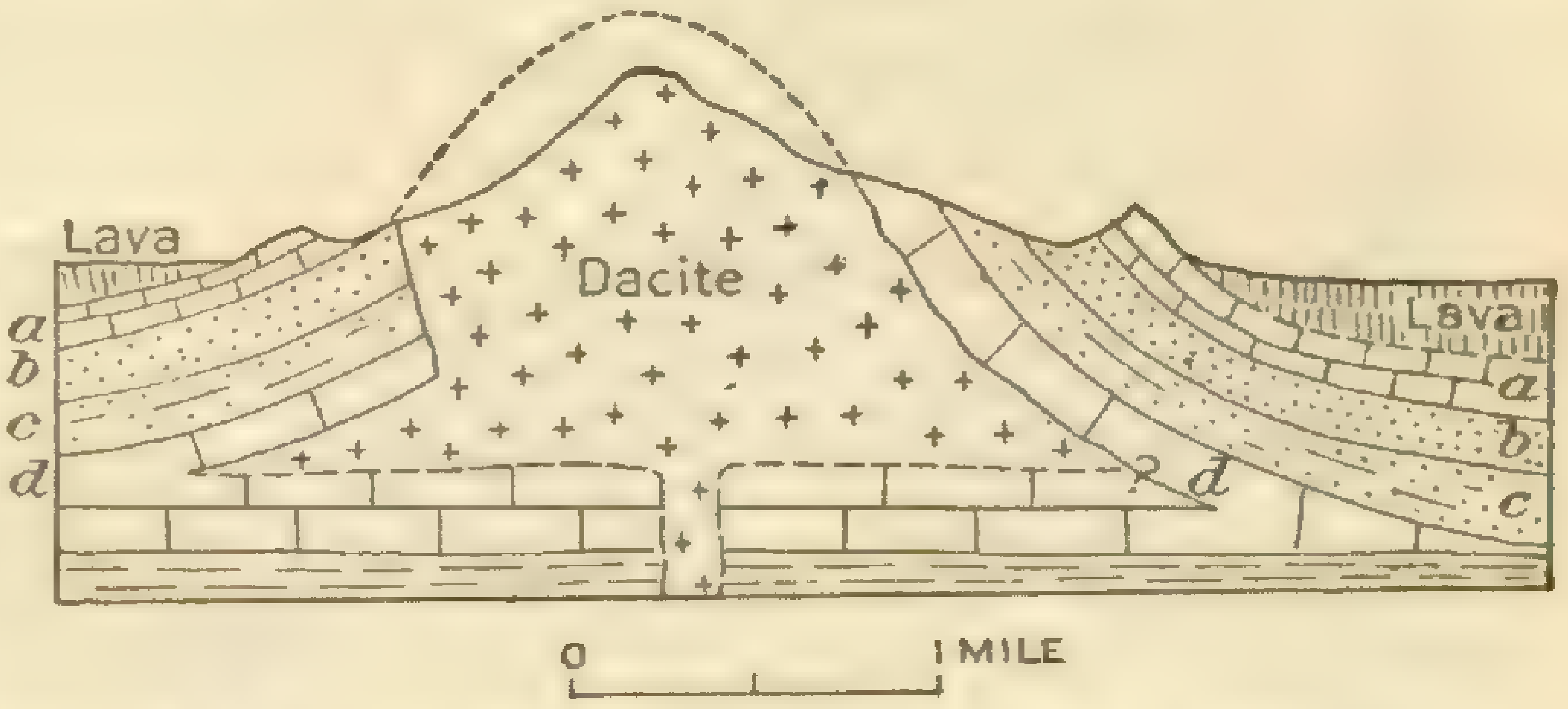


FIGURE 25.—Section of Elden Mountain, east of Flagstaff, Ariz., showing relations of beds upturned on its east side. *a*, Limestone (Kaibab); *b*, gray sandstone (Coconino); *c*, red sandstone (Supai); *d*, limestone (Redwall); *e*, igneous rock. (After H. H. Robinson.)

Cliffs.

Elevation 6,829 feet.
Kansas City 1,260 miles.

At Cliffs the train runs near the south edge of Elden Mountain, a prominent mass of dark-colored dacite of the second period of volcanic activity. The lava is in heavy beds presenting an arched appearance, suggesting strongly that the lava was poured out in thick viscous layers which were finally bent upward by the pushing of some central force at or toward the end of the period of eruption. That this range has been considerably upthrust is further indicated by the presence of some large uplifted masses of the sedimentary rocks of the plateau along its east side. In this uplift are exposed the Redwall limestone, the red sandstone of the Supai formation, the Coconino sandstone, and the Kaibab limestone, all dipping steeply eastward with the relations shown in figure 25.

Half a mile south of Cliffs there are some remarkable sink holes in the bottom of the valley, known as the Bottomless Pits (Pl. XXVIII). They form the entrance to a cavern in the Kaibab limestone made by the solvent action of water on the limestone in its passage underground through joints and fissures to outlets in the depths of Walnut Canyon, a few miles south.

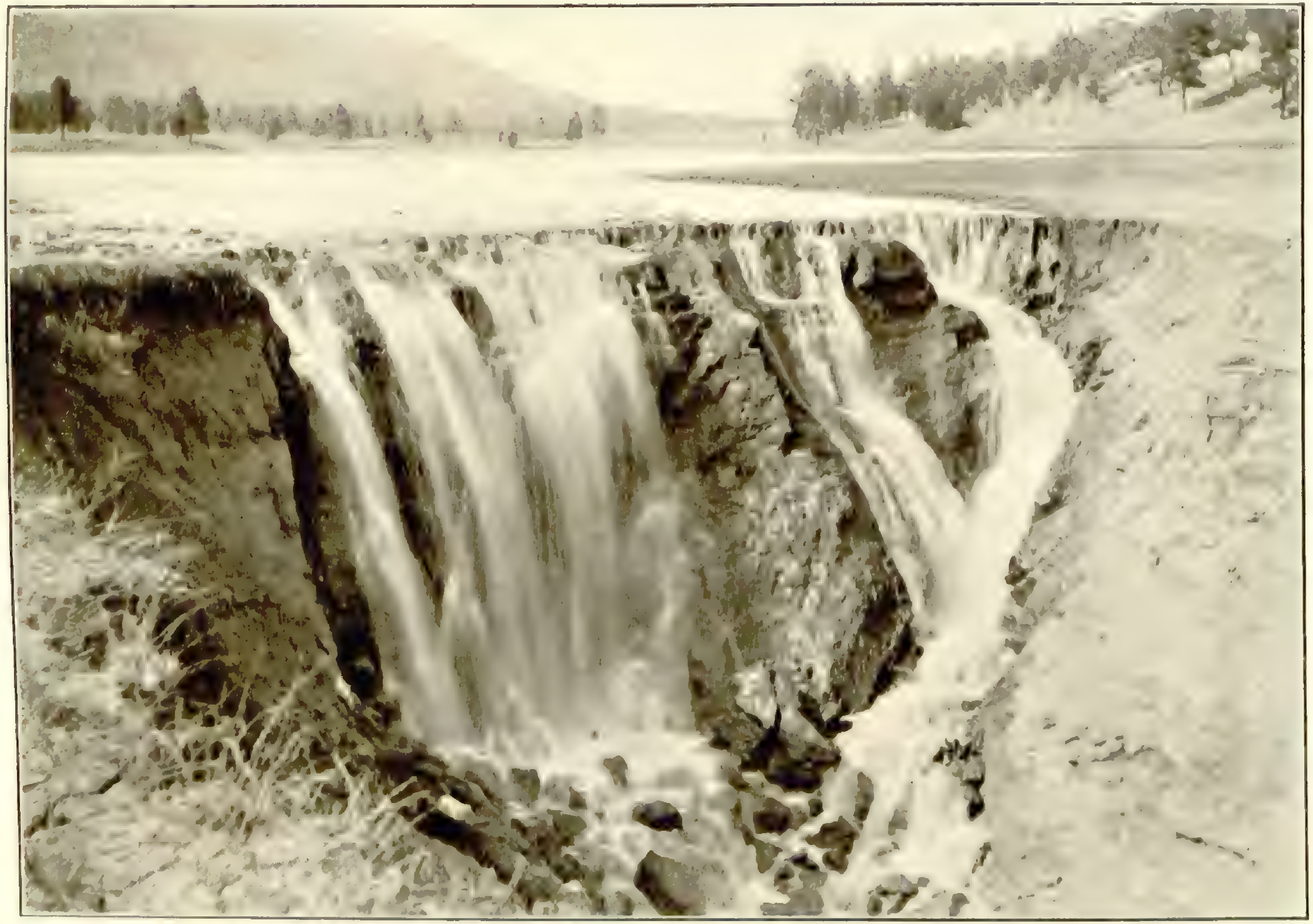
Along the walls of this canyon, 5 miles southeast of Cliffs, is a well-known group of cliff dwellings, shown in Plate XXIX, *A*. They belonged to Indians of a race that existed many centuries ago and lived hidden in these canyons. They built stone houses under the overhanging ledges of limestone a hundred feet above the stream bed. These ledges are due to the variations in hardness of the beds of Kaibab limestone, the soft beds weathering away, leaving the hard beds in the form of ledges. One soft bed in particular which has weathered out along both sides of Walnut Canyon for some distance gave the Indians an excellent site for many houses of this character. It has been estimated that 1,000 persons lived in these cliff dwellings, which are easily accessible by an excellent carriage road from Flagstaff, the principal town of this region.

A short distance beyond milepost 342 the railway passes along the north edge of a small lava field occupying a valley, and in slopes north of the track is an outlying mass of the red Moencopie sandstone, which extends for a mile and a half, or nearly to Flagstaff. The sandstone is overlain by an older sheet of lava (basalt), which caps the mesa northeast of Flagstaff. This sandstone has been extensively quarried a few rods north of milepost 343, furnishing a beautiful red stone which has been used at many places in the West, notably in the Brown Palace Hotel, Denver, and the city hall at Los Angeles.

Flagstaff is a growing city, largely sustained by the lumbering business and surrounding ranches. It was named from a pole set by a party of immigrants who camped near by and celebrated the Fourth of July. Formerly it was the point of departure for stages for the Grand Canyon, 60 miles to the northwest, but this service has been mostly superseded by the railway line from Williams. An excellent road, however, has been built to the canyon. It passes around the east side of the Elden and San Francisco mountains to a point near Sunset Peak and thence north across the volcanic field and plateau, reaching the edge of the canyon at Grandview. When conditions are favorable this trip can be made in five or six hours by automobile.

Flagstaff.
Elevation 6,896 feet.
Population 1,633.
Kansas City 1,265 miles.

There are large lumber mills at Flagstaff deriving much of their supply from the pine timber of the Coconino National Forest, which they purchase "on the stump" from the Government. In accordance with the regulations of the Forest Service, only the mature trees are cut. The average age of old pine trees in the Coconino Forest has been determined to be 348 years, but some have been found as old as 520 years, dating back a century before the first visit of Columbus to America. Recent investigations made to ascertain rainfall conditions in the past as indicated by variations in rings of growth

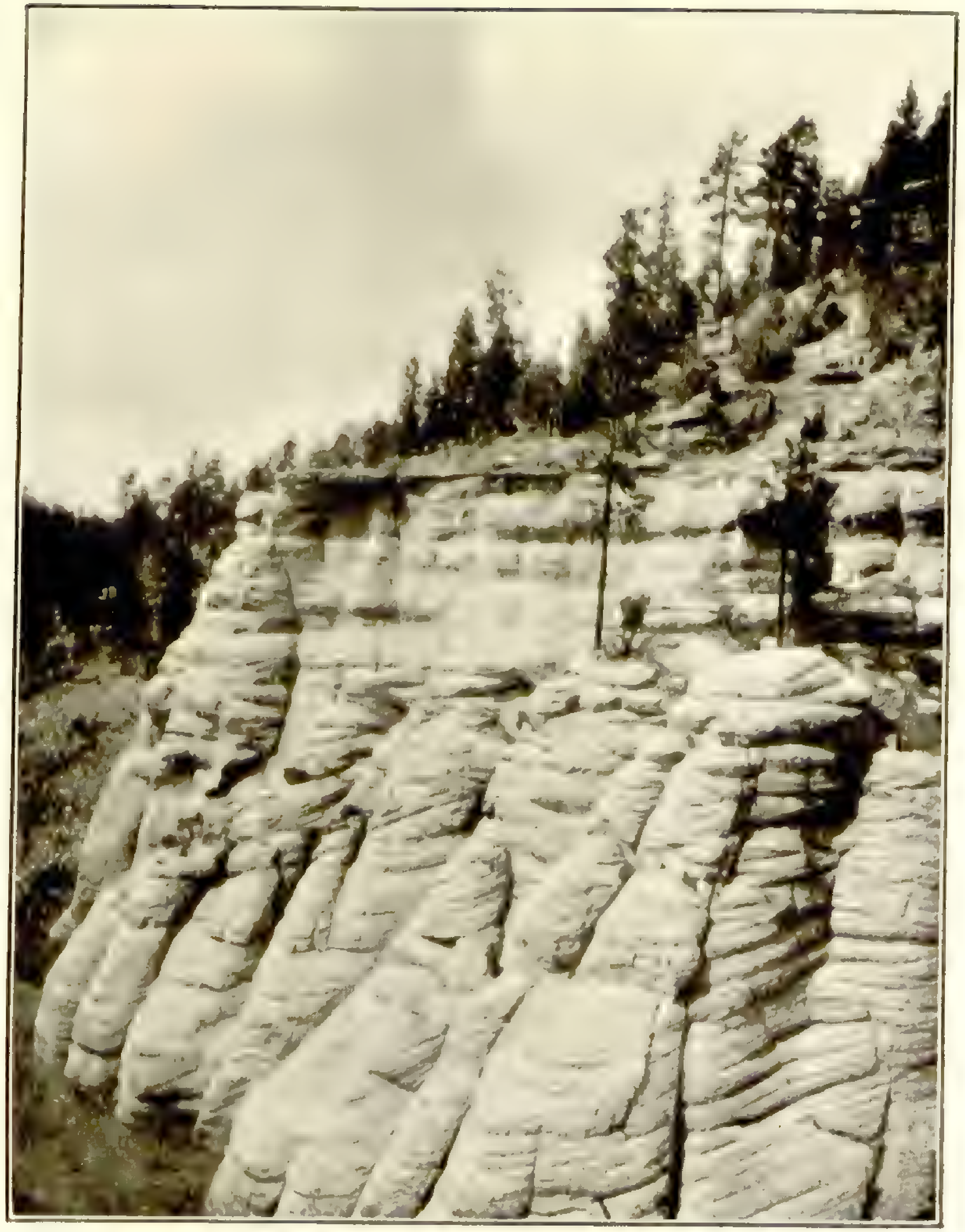


BOTTOMLESS PITS SOUTH OF CLIFFS, EIGHT MILES SOUTHEAST OF FLAGSTAFF, ARIZ.

The water passes into a sink or cave formed by the solution of Kaibab limestone.

A. CLIFF DWELLINGS IN WALNUT CANYON, SOUTHEAST OF FLAGSTAFF, ARIZ.

Ruins of houses are under overhanging cliff of Kaibab limestone.



B. CROSS-BEDDING IN COCONINO SANDSTONE IN WALNUT CANYON, ARIZ.

The cross-bedding, which is diagonal to the regular bedding, was produced by strong currents that varied in direction as they deposited the sand.

in trees show marked changes in climate in alternating long cycles of drier and more rainy periods.

On the edge of the high mesa in the western part of Flagstaff is the Lowell Observatory, which is equipped with an especially fine telescope through which Dr. Percival Lowell and his assistants have made their famous observations on the planet Mars. The clear, steady air of this high altitude is particularly favorable for astronomical work.

The peaks of the San Francisco Mountains[1] are prominent from Flagstaff, and the trip to their summit can easily be made on horseback from that place. The region from these mountains to Gila River was the domain of the Apaches (Pinal Coyote) until their final surrender through the efforts of Gen. Crook and Gen. Miles in 1886. At one time the San Francisco Mountains were the refuge of the Havasupai Indians, who fled there when driven from their home on the Little Colorado. These Indians are the only ones among the Yuman tribes who had a culture similar to that of the Pueblo people farther east. A number of ruins are ascribed to them as far south as the Rio Verde, in central Arizona, and the early name Cosnino, by which this tribe was known, has been applied to many features in this region. They now live in Cataract Canyon, 60 miles northwest of Williams.

West of Flagstaff the train continues to climb up the plateau slope. In this vicinity the Kaibab limestone is mostly covered by lavas of various kinds, but its surface appears for a short distance in a depression just west of Flagstaff. For the first 5 miles west the railroad passes along the southern foot of a mesa consisting of a light-gray lava (latite), poured out over the surface in a thick mass during the second period of volcanic activity.

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[1] The structure of these mountains is shown in figure 26. They consist of a thick pile of latite lying on a sheet of earlier basalt and overlain by flows of other lava, mainly dacite and andesite. These rocks appear to lie on the limestone platform of the plateau, but the beds may be upturned, and possibly some Moencopie sandstone may underlie the central mass of latite.

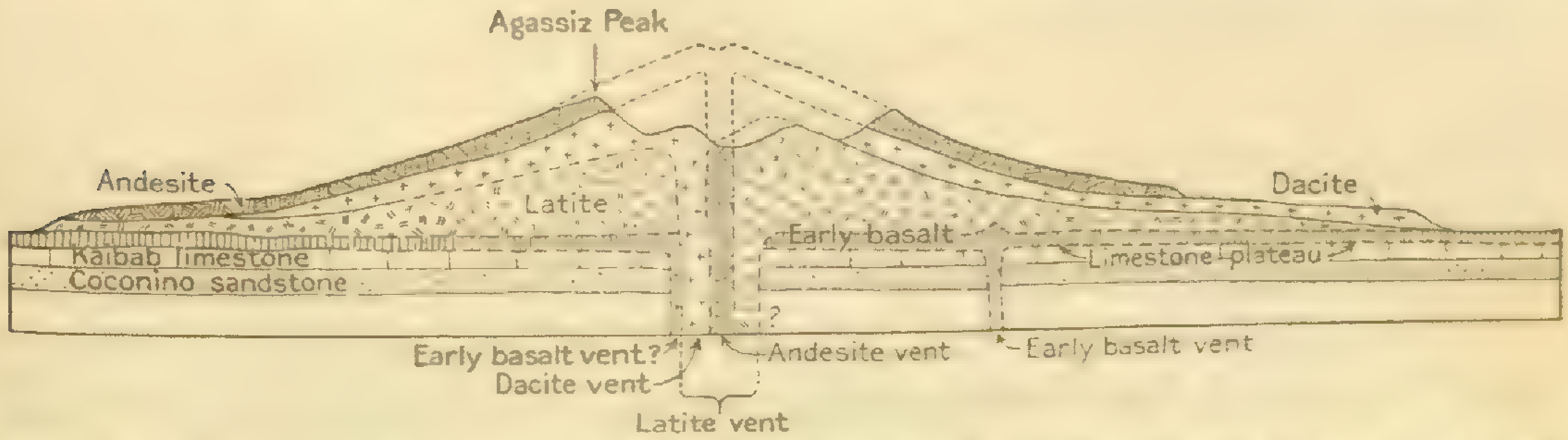


FIGURE 26.—Generalized section through the San Francisco Mountains, northeast of Flagstaff, Ariz., looking north. Dotted portion eroded; broken line hypothetical.

Riordan.

Elevation 7,311 feet.
Kansas City 1,272 miles.

Just east of Riordan siding, eight-tenths of a mile beyond milepost 350, the Arizona Divide is crossed at an altitude of 7,311 feet, the highest point reached by the railway on the plateau. At this place and westward to and beyond Williams the surface is dark lava (basalt) of somewhat irregular configuration, with many large cinder cones on every side.

Bellemont.

Elevation 7,132 feet.
Population 692.*
Kansas City 1,277 miles.

Bellemont is in a wide "park" or open space in the forest, near the southern edge of one of the large lava flows. A short distance to the south, where the lava lies on limestone, there are copious springs of exceptionally good water. This water is derived from rain and melting snow on the surface of the lava. It percolates through the porous rock to the underlying limestone and flows along the surface of the limestone to its outcrop. It is pumped to the station and used on the railway. On a well-watered flat north of this station is probably the heaviest stand of timber in Arizona or New Mexico.

At Nevin siding, 2 miles west of Bellemont, a small cinder cone has afforded the railway company a supply of ballast which has been used on the tracks for many miles to the east and west. The pit, which is north of the siding, is large and presents an especially fine section through the cone. The principal working face, nearly 100 feet high, shows thick beds of cinders with large numbers of scattered bombs of various sizes and flattened masses of lava which have been thrown out bodily. The vent from which all this material was ejected has not been exposed by the excavations. As in many other cones, much of the material is red, owing to the oxidation of the iron which the lava contains. This oxidation develops more extensively in the cinder or bombs than in the solid basalt, for air and water, which facilitate the oxidation, have more complete access to material that is in the porous form.

South of Nevin is Volunteer Mountain, a very large pile of cinders including some hard layers which appear to have been mud flows and consist of cinders that evidently flowed out mixed with more or less water and are now cemented into a porous rock. There are other thick piles of cinders to the north and northwest of Nevin and Maine.

Maine.

Elevation 7,084 feet.
Kansas City 1,283 miles.

From Bellemont westward at intervals to and beyond Maine (see sheet 19, p. 122) there are excellent views of Kendrick Peak, which is 12 miles north of Bellemont, and of Mount Sitgreaves, which is 8 miles northwest of Maine. These peaks are due to thick masses of lavas of the viscous type poured out during the second period of eruption and rising high above the plain of older basalt. The mass culminating in Mount Sitgreaves consists mainly of rhyolite; the principal rocks in

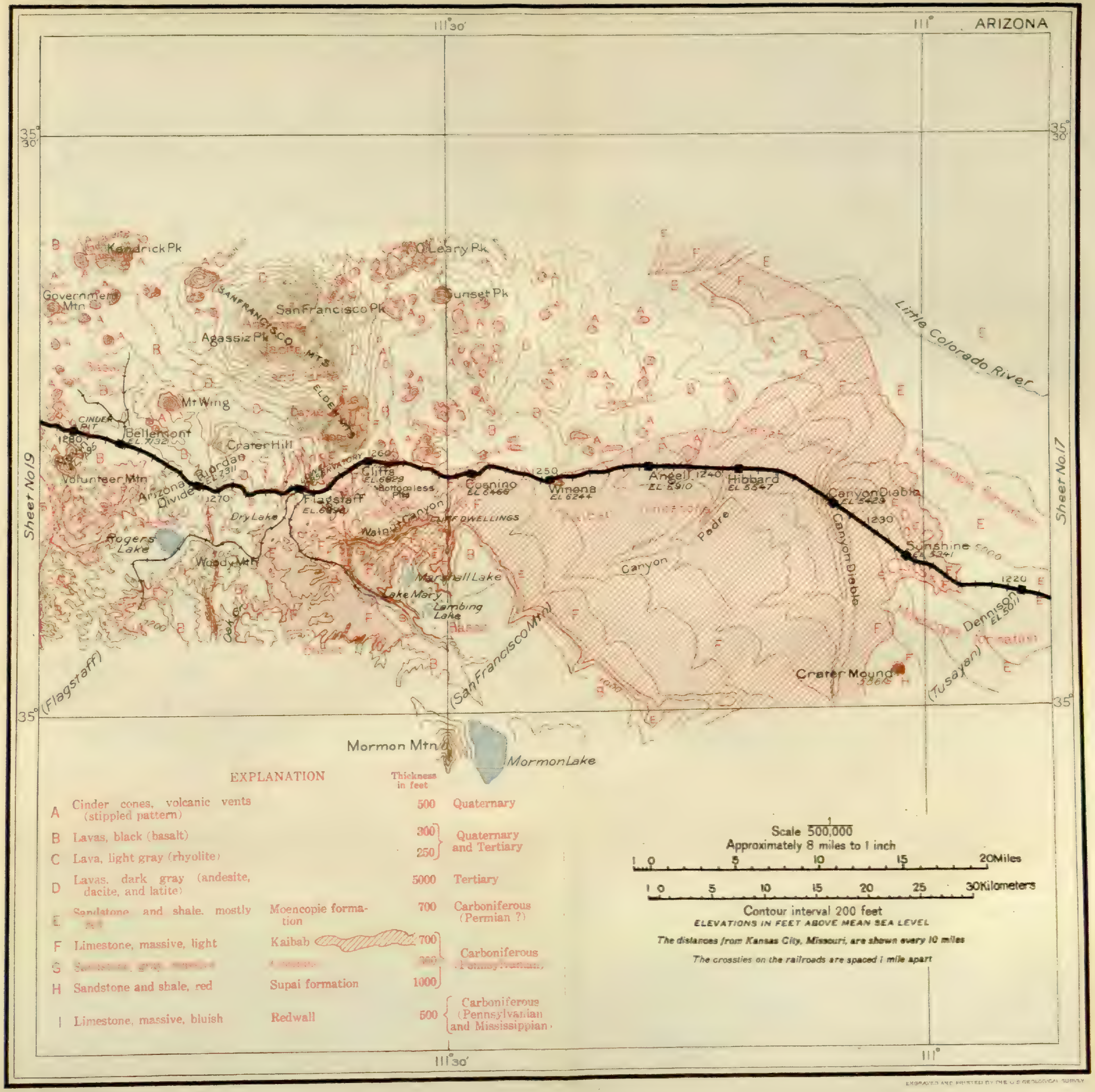
GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
SANTA FE ROUTE
From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.


ARIZONA
111°30'
111°
35° 30'
35°
Sheet No.19
Sheet No.17
Kendrick Pk
Government Mtn
San Francisco Pk
SAN FRANCISCO MTS
Agassiz Pk
O'Leary Pk
Sunset Pk
Mt Wing
ELDEN MTN
Little Colorado River
CINDER PIT
Bellemont EL 7132
Crater Hill
Riordan EL 7311
Arizona Divide
Volunteer Mtn
1280
1270
1260
1250
1240
1230
1220
Flagstaff EL 6896
Cliffs EL 6829
Bottomless Pits
Cosnino EL 6466
Winona EL 6244
Angell EL 5910
Hibbard EL 5547
Canyon Diablo EL 5429
Sunshine EL 5241
Dennison EL 5011
Dry Lake
Walnut Canyon
CLIFF DWELLINGS
Rogers Lake
Woody Mtn
Marshall Lake
Lake Mary
Lambing Lake
Oak Cr.
Padre Canyon
Canyon Diablo
San Francisco Mtn
Crater Mound 5366
(Flagstaff)
(San Francisco Mtn)
(Tusayan)
Mormon Mtn
Mormon Lake
EXPLANATION
Thickness in feet
A Cinder cones, volcanic vents (stippled pattern) 500 Quaternary
B Lavas, black (basalt) 300 Quaternary and Tertiary
C Lava, light gray (rhyolite) 250 Quaternary and Tertiary
D Lavas, dark gray (andesite, dacite, and latite) 5000 Tertiary
E Sandstone and shale, mostly red Moencopie formation 700 Carboniferous (Permian ?)
F Limestone, massive, light Kaibab 700 Carboniferous (Pennsylvanian)
G Sandstone, gray, massive Coconino 300 Carboniferous (Pennsylvanian)
H Sandstone and shale, red Supai formation 1000 Carboniferous (Pennsylvanian)
I Limestone, massive, bluish Redwall 500 Carboniferous (Pennsylvanian and Mississippian)
Scale 1/500,000
Approximately 8 miles to 1 inch
0 5 10 15 20 Miles
0 5 10 15 20 25 30 Kilometers
Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart
ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

Kendrick Peak are andesite and dacite. Mount Sitgreaves received its name from an Army officer who explored this country in order to find a suitable line for a road to the West. He crossed from Zuni by way of the San Francisco Mountains to the Colorado above Mohave River.

From Maine to Williams there are to the north and south many large cinder cones, mostly of red color. To the southwest rises Bill Williams Mountain, named for a noted trapper who was originally a Methodist preacher in Missouri. He lived with many Indian tribes and learned their language, an accomplishment which made him useful as a guide, and he was with Gen. Frémont in his expedition. He was finally killed by Indians while trading with them.

Bill Williams Mountain is a huge isolated pile of andesite and dacite of the second stage of eruption, forming a prominent landmark for many miles in all directions. It is a short distance south of Williams and rises to an altitude of 9,642 feet. Some of the same kind of rock as that of which the mountain consists is exposed in the railway cut a short distance east of Williams.

Williams.
Elevation 6,762 feet.
Population 1,267.
Kansas City 1,299 miles.

Williams is a growing village sustained very largely by the lumber industry and numerous neighboring ranches. Several large mills cut into lumber logs brought from the west side of the Tusayan National Forest, a reservation covering the western part of the great forest beginning east of Flagstaff, of which the Coconino National Forest is the eastern part. The hotel at Williams, the Fray Marcos, was named from Marcos de Niza, who was the provincial father of the order of Franciscans in New Spain. He made an expedition into this unknown country in 1539, guided by the negro Estevan, who had accompanied Cabeza de Vaca in his earlier expedition from the Gulf of Mexico across what is now the southern border of the United States and who, on meeting the Spanish conquistadores in Sinaloa, aroused their interest in the exploration of this region. Estevan went ahead into Cibola (Zuni) and was slain, the Indians doubting his story that white men were following him, because he was black. On hearing of Estevan's fate Fray Marcos retreated to Mexico, but he returned the next year as guide and spiritual director of Coronado's expedition.

[The itinerary westward from Williams is continued on p. 131.]

WILLIAMS TO GRAND CANYON.

From Williams a branch of the Santa Fe Railway runs nearly due north 63.8 miles to the Grand Canyon. In the first part of its course this line passes over a rolling plateau of black lava (basalt) with numerous cinder cones on all sides. One notably large cone of bright-red color is 7 miles north of Williams, and there is another one 10 miles north. Between mileposts 13 and 15 the Kaibab limestone, which underlies the lava, appears at the surface in several localities, but the irregular margin of the lava extends to milepost 18. From several points there are excellent views of Mount Sitgreaves to the east and Kendrick Peak to the northeast.

Beyond milepost 18 the entire surface is Kaibab limestone, which constitutes most of the great Arizona Plateau. This limestone rises gradually northward to the rim of the Grand Canyon and is trenched at intervals by small valleys opening westward and draining into Cataract Creek, a stream which flows into the Grand Canyon 60 miles to the northwest. In this region the plateau does not bear the pine forest which is so characteristic of it farther east, and even the junipers and piñons are widely scattered, much of the surface being covered by small brush. This change is due to diminished rainfall, for the other conditions are identical with those found farther east.

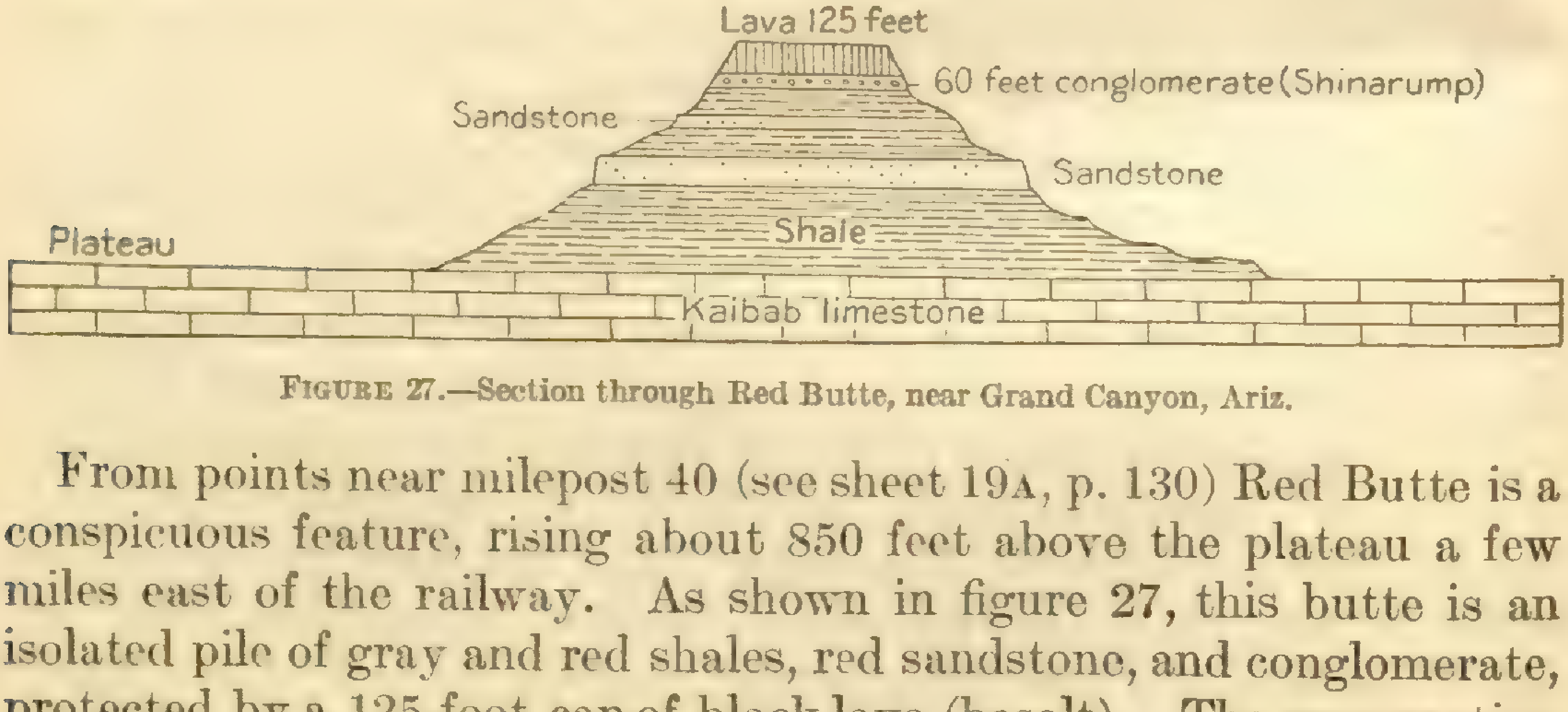


FIGURE 27.—Section through Red Butte, near Grand Canyon, Ariz.

From points near milepost 40 (see sheet 19A, p. 130) Red Butte is a conspicuous feature, rising about 850 feet above the plateau a few miles east of the railway. As shown in figure 27, this butte is an isolated pile of gray and red shales, red sandstone, and conglomerate, protected by a 125-foot cap of black lava (basalt). The preservation of these beds in this butte is of great interest, for it shows that younger rocks formerly covered the Kaibab limestone of the plateau to a thickness of at least 800 feet. These rocks have been removed by erosion over the wide area extending to Sunset and Winslow on the east, and to the Vermilion Cliffs, far north of the Grand Canyon, as well as for an undetermined distance to the west and south. The small remnant remaining in Red Butte has been protected by hard basalt, probably a local outflow of lava of no great extent.

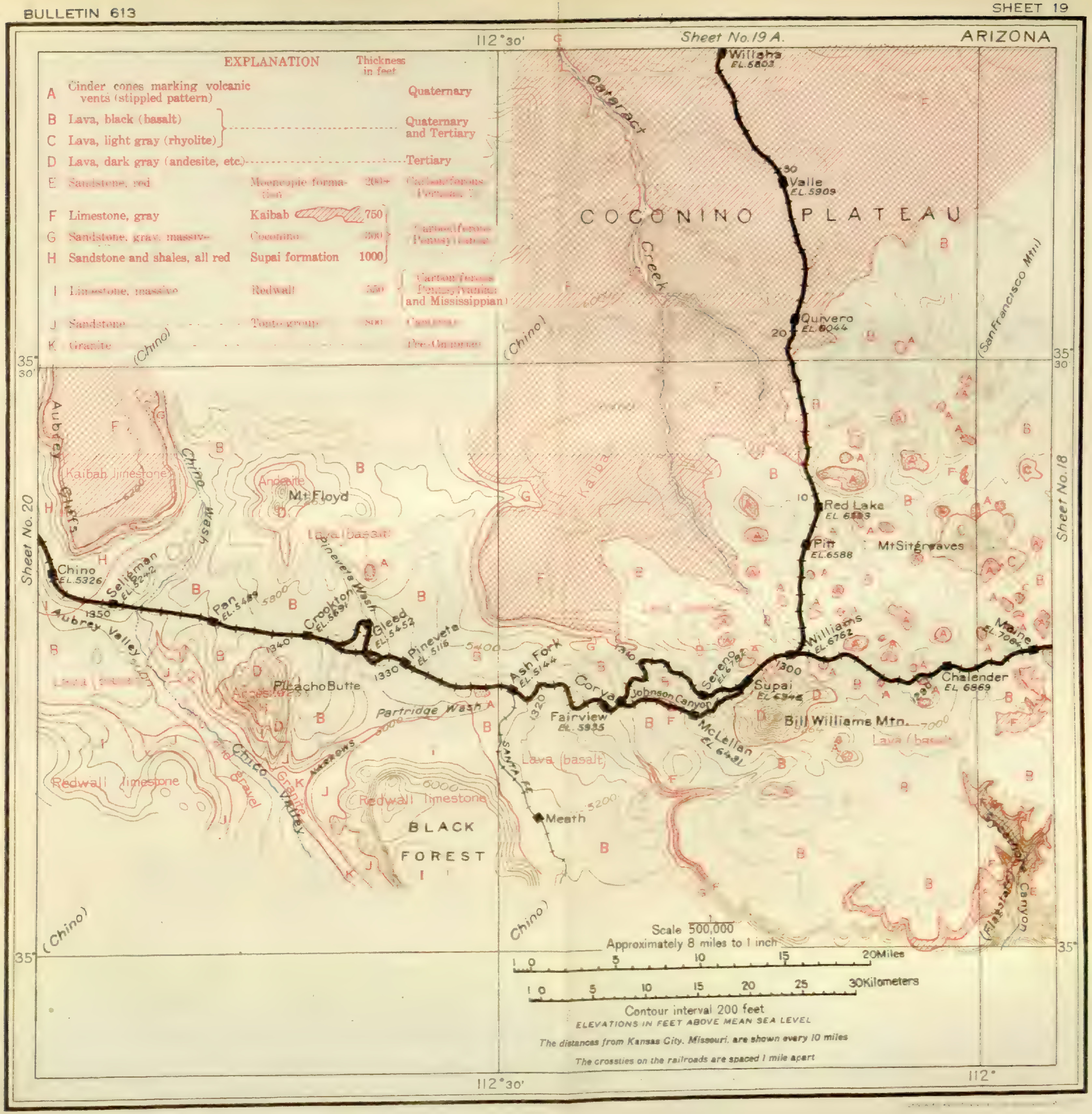
By the presence of this outlier it is possible to recognize some of the geographic conditions existing at a time when the plateau was developed on the surface of higher strata than it is at present and when it may have been as extensive and as level as now. A few other outliers of these rocks overlying the Kaibab limestone at several points on the plateau help to show that originally the rocks of which they consist extended over a wide region south of the Grand Canyon.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
SANTA FE ROUTE
From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist R. B. Marshall, Chief Geographer
1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.



	EXPLANATION		Thickness in feet	
A	Cinder cones marking volcanic vents (stippled pattern)			Quaternary
B	Lava, black (basalt)			Quaternary and Tertiary
C	Lava, light gray (rhyolite)			
D	Lava, dark gray (andesite, etc.)			Tertiary
E	Sandstone, red	Moenkopie formation	200+	Carboniferous (Permian ?)
F	Limestone, gray	Kaibab ▨	750	Carboniferous (Pennsylvanian)
G	Sandstone, gray, massive	Coconino	300	
H	Sandstone and shales, all red	Supai formation	1000	
I	Limestone, massive	Redwall	550	Carboniferous (Pennsylvanian and Mississippian)
J	Sandstone	Tonto group	800	Cambrian
K	Granite			Pre-Cambrian

Scale 1/500,000
Approximately 8 miles to 1 inch
0 5 10 15 20 Miles
0 5 10 15 20 25 30 Kilometers
Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart

Anita is a small siding from which considerable copper ore was shipped some years ago. The mines were 4 miles to the northeast. The copper ore occurs in irregular masses in the Kaibab limestone. It has been brought by underground solutions and deposited in part as a replacement of the limestone and in part in crevices and fissures in that rock.

At milepost 50, near Hopi siding, junipers and piñons appear more abundantly, and toward the edge of the canyon they constitute a thick growth at most places and in parts of the region east of the railway make a forest of considerable extent. From Hopi northward ledges of Kaibab limestone become conspicuous. The beds dip to the south at a very low angle, which is hardly perceptible to the eye. Owing to this tilt in the beds, they rise toward the canyon and northward. The railway terminus is in a small depression a few rods south of the brink of the Grand Canyon.

Grand Canyon.
Elevation 6,866 feet.
Population 299.*
Kansas City 1,363 miles.

The hotels are built on the edge of a deep alcove that affords a superb view into the Grand Canyon and across it to the great Kaibab Plateau on the north side. Few persons can realize on a first view of the canyon that it is more than a mile deep and from 8 to 10 miles wide. The cliffs descending to its depths form a succession of huge steps, each 300 to 500 feet high, with steep rocky slopes between. The cliffs are the edges of hard beds of limestone or sandstone; the intervening slopes mark the outcrops of softer beds. This series of beds is more than 3,600 feet thick, and the beds lie nearly horizontal. Far down in the canyon is a broad shelf caused by the hard sandstone at the base of this series, deeply trenched by a narrow inner canyon cut a thousand feet or more into the underlying "granite." (See Pl. XXXIII, p. 127.) The rocks vary in color from white and buff to red and pale green. They present a marvelous variety of picturesque forms, mostly on a titanic scale, fashioned mainly by erosion by running water, the agent which has excavated the canyon.

The great river which has made its course in this deep canyon is the Colorado, one of the largest rivers of North America, which rises in the Rocky Mountains in Colorado and Wyoming and empties into the Gulf of California. In the Grand Canyon it is a stream about 300 feet wide and 30 feet deep at mean stage and flows with a mean velocity of about 2 miles an hour; the discharge at this stage is 26,400 cubic feet a second. At flood stages, in May, June, or July, the depth may reach 100 feet, and the velocity and volume are greatly increased. In its course of 42 miles through the central part of the canyon the river falls about 500 feet, or 12 feet to the mile. The water contains much sediment, and in time of flood not only carries a large quantity of sand and clay but moves a considerable amount of rock downstream.[1] Every rain fills the side canyons with rushing torrents, which carry into the river a heavy load of débris washed from the adjoining slopes. It has been by this means that the canyon was excavated, and the deepening and widening process is still in active operation. It began at the surface of the plateau and it will continue until the river reaches a grade so low that it can no longer move the débris; meanwhile the side streams will cut away the adjoining slopes and the canyon will widen until its sides become gentle slopes. Under present conditions this will require a million years or more.

Rocks.

The formations exposed in the walls of the Grand Canyon are the rocks which underlie the Arizona Plateau, and most of them extend far beyond that province. The first 3,600 feet of beds, all of which lie nearly horizontal, are as follows:

Strata above granite, in walls of Grand Canyon (beginning at brink of the canyon).

		Feet.
Limestone, light colored, partly cherty, mostly massive (Kaibab)		700
Sandstone, light gray, massive, cross-bedded (Coconino)		300
Sandstones and shales, all red (Supai formation)		1, 100
Limestone, light blue-gray, massive, surface mostly stained red (Redwall)		550
Shale, with limestone and sandstone layers	Tonto group	800
Sandstone, hard, dirty gray to buff (on granite)		150

These formations are readily recognized by their color or character, as they are practically uniform in aspect and relative position from all points of view. (See Pl. XXXII, p. 126.) The top limestone, which caps the great plateaus on both sides of the canyon, has been removed in whole or in part from some of the promontories and buttes that project into the canyon; the Coconino, Supai, or Redwall beds have been removed from the lower-lying features. The outcropping edge of the Coconino sandstone[2] is marked by a distinct band of light-gray rock all along the canyon walls 700 to 800 feet below the top. The red beds of the Supai formation[3] everywhere constitute the middle slopes of the canyon walls, usually presenting a great series of terrace-like steps of red sandstone. These steps are caused by the projection of harder layers of sandstone. The Redwall limestone [1] forms a conspicuous cliff at the foot of the Supai slopes. The rock is hard and massive, and its resistance to erosion makes it a prominent feature in the canyon. Its surface is stained red by wash and drippings from the overlying red shales.

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[1] A very large amount of material is removed from the land and carried to the oceans by all rivers. Careful estimates based on analyses of river waters and measurements of volume of flow have shown that in a year the rivers of the United States carry to tidewater 513,000,000 tons of sediment in suspension and 270,000,000 tons of dissolved matter. The total of 783,000,000 tons represents more than 350,000,000 cubic yards of rocks, or a cube of about two-fifths of a mile.

[2] This sandstone also caps many buttes such as Isis, Osiris, and Manu temples, and Angels Gate, as well as Buddha, Zoroaster, Brahma, Deva, and Vishnu temples and other similar features on which more or less of the overlying limestone remains.

[3] Such features as O'Neill Butte, Newton Butte, Tower of Set, Tower of Ra, Horus Temple, Rama Shrine, Lyell Butte, and Sagittarius Ridge consist of the Supai formation. It also is conspicuous in the slopes of many great ridges capped by higher beds, such as Shiva Temple, Wotan's Throne, Brahma Temple, Osiris Temple, Zoroaster Temple, and Vishnu Temple.

The Redwall and the overlying Supai, Coconino, and Kaibab beds represent the greater part of the Carboniferous period. (See p. ii.) The Supai, Coconino, and Kaibab are of about the same age as the limestones along the Santa Fe line from Kansas City to Strong City, Kans., but there is a marked difference in their character.

The Tonto group, below the Redwall, consists of 800 feet of shales, largely of greenish color, and a basal sandstone averaging 150 feet in thickness. This group is very much older than the Redwall, and though at their contact the beds of the one are practically parallel to the beds of the other, there is a hiatus here which represents a very considerable portion of geologic time not represented by rocks in this region but recorded by many thousand feet of rocks in other portions of North America and in other countries. The shales make a long slope, interrupted by some subordinate ledges of limestone and sandstone, descending to a pronounced shelf of the sandstone, called the Tonto Platform. This slope and the wide shelf at its foot are both very characteristic and easily recognized features extending along the lower slopes of the Grand Canyon.

For many miles this shelf of sandstone of the Tonto group is cut through by the steep inner gorge (shown in Pl. XXXIII, p. 127), which descends to the river, 800 to 1,000 feet below, and exposes the underlying granite and gneiss in very dark rugged ledges. These rocks are part of the old earth crust, which has been subjected to great heat and pressure. Later in its history its surface was worn down to a plane upon which were deposited thick beds of sand, clay, and other materials. In a wide area the basal sandstone of the Tonto lies directly on the smooth surface of this schist and granite, but in some places, notably in the broad part of the canyon northeast of Grandview, in Shinumo basin, in part of Bright Angel Canyon, in Ottoman and Hindu amphitheaters, and in the ridges extending northwest and southeast from a point near the mouth of Bright Angel Creek other rocks lie between the granite and the Tonto rocks. These are a succession known as Grand Canyon series, comprising the Unkar and Chuar groups, all named from localities in the canyon where they are well exposed. Their thickness is 12,000 feet or more and the beds dip at moderately steep angles. Their surface has also been worn off to a rolling plain, with many local hills on which lie the shales of the Tonto group. The Unkar group, which is the one exposed from most points of view, consists of a succession of basal conglomerates, dark limestone in thick beds, bright-red shales, heavy quartzites, and brown sandstones.[1] This succession of rocks is plainly visible in Bright Angel Canyon and in the ridge culminating in Cheops Pyramid (see Pl. XXX), also in a wide area along the river in the region northeast of Grandview Point.

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[1] The Redwall limestone projects in many flat-topped spurs and buttresses and constitutes outliers isolated by erosion, such as Cheops Temple, Newberry Butte, and Sheba Temple, which form striking topographic features.

Many interesting features of the geologic history of the plateau region are recorded in the rocks of the Grand Canyon, and a summary of these records is given below.[2]

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[1] These rocks have been named Hotauta conglomerate, Bass limestone, Hakatai shale, Shinumo quartzite, and Dox sandstone.

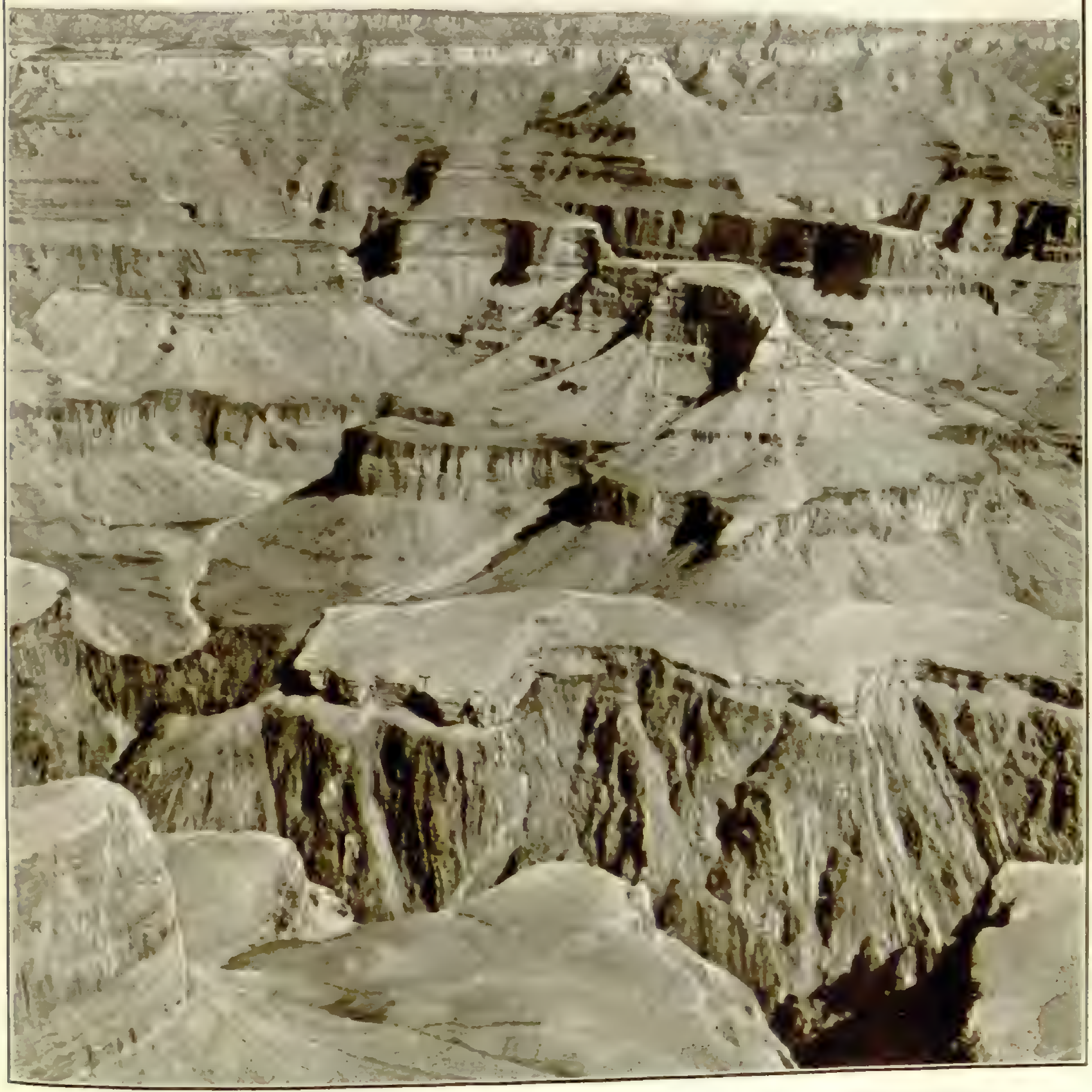
[2] The granite and gneiss at the bottom of the canyon are part of the oldest group of rocks constituting the earth's crust. The gneiss, which is the older, is in nearly vertical layers. It has been subjected to great heat and pressure, and into it the granite was forced in a molten state. Later the surface of these rocks was eroded to a plain by running water.

The next event of which there is evidence was the submergence of this plain and the deposition in water, of varying depth, of a thick series of sediments now represented by the 12,000 feet or more of sandstone, limestone, and shale constituting the Unkar and Chuar groups. These strata are believed to represent the Algonkian period (see p. ii), the earliest in which remains of life have been found. Several million years was required for the accumulation of these sediments. The materials of the limestone were laid down in the sea, those of the sandstone on beaches and along streams, and those of the shale mostly in estuaries.

Next there was extensive uplifting of the earth's crust, with tilting and faulting of the rocks. Erosion then swept away a large amount of the Unkar and Chuar sediments, and over wide areas they were all removed. In figure 28 are shown some conditions of this sequence of events, as indicated by the relations of the rocks on the north side of the river opposite El Tovar.

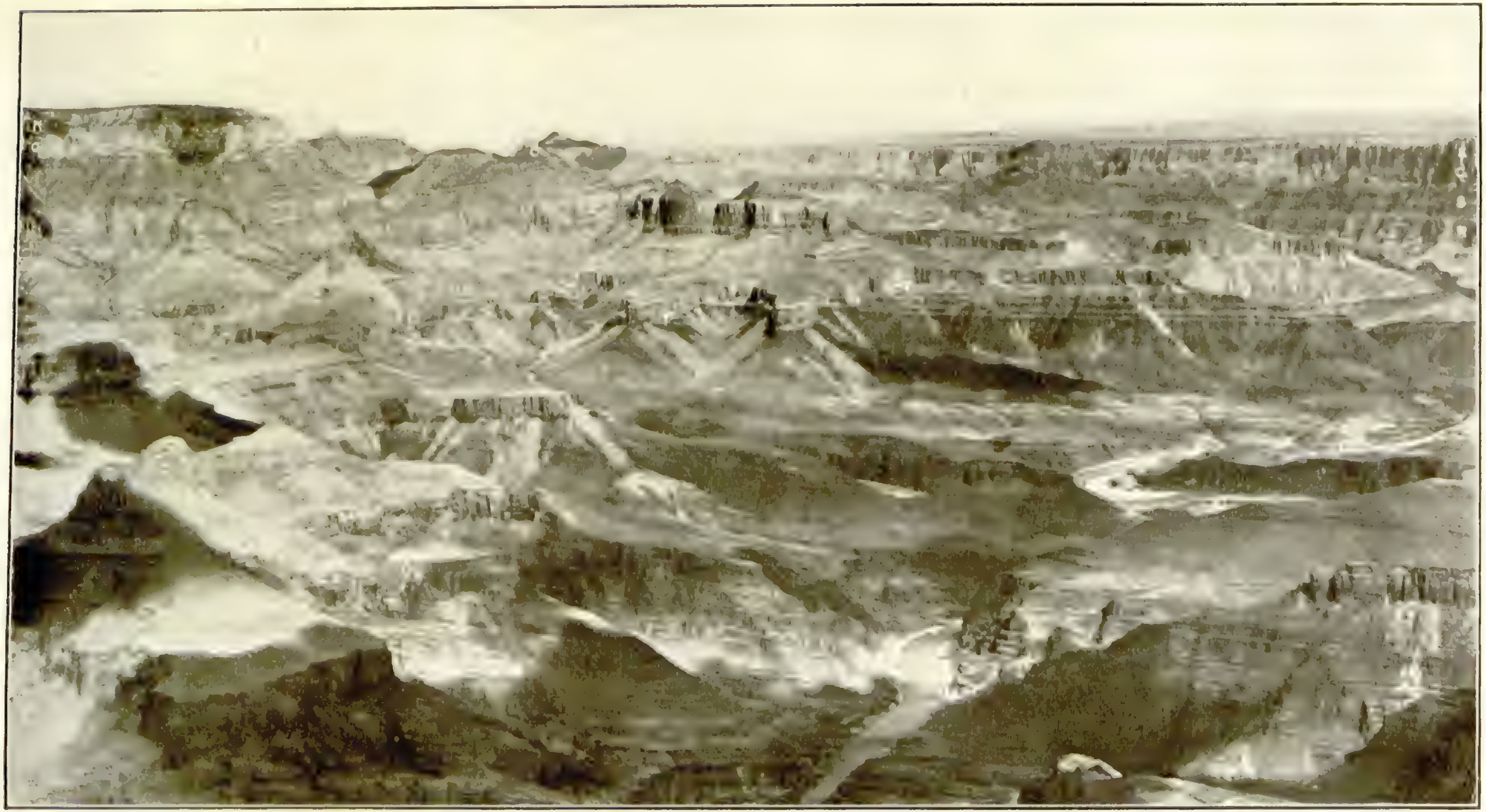
When the surface was reduced to a rolling plain with a few hills rising in places, there was another submergence by the sea, which deposited the sediments of the Tonto group. First the sand was deposited over the smooth granite surface (as shown by the heavy line in fig. 28, *B*). With deepening waters or diminishing force of the currents, the clay now represented by the shale of the Tonto group was laid down, soon burying the islands of Unkar and Chuar rocks and accumulating to a thickness of 800 feet or more. Remains of life in these rocks indicate that they represent a portion of later Cambrian time. The conditions in this region during the next three long and very important geologic periods are not known, for their representatives are absent except a small amount of the Devonian rocks found at one or two places. The sea may have laid down here, during those periods, deposits of great thickness, which were later uplifted into land areas, so that they were removed by streams and other agents of erosion.

In early Carboniferous time, the period characterized in other parts of the world by the accumulation of the older coal-bearing deposits, the entire region was submerged by the sea, which deposited calcium carbonate in nearly pure condition, now represented by 500 feet or more of the Redwall limestone. Much calcium is carried into the sea by streams, and its



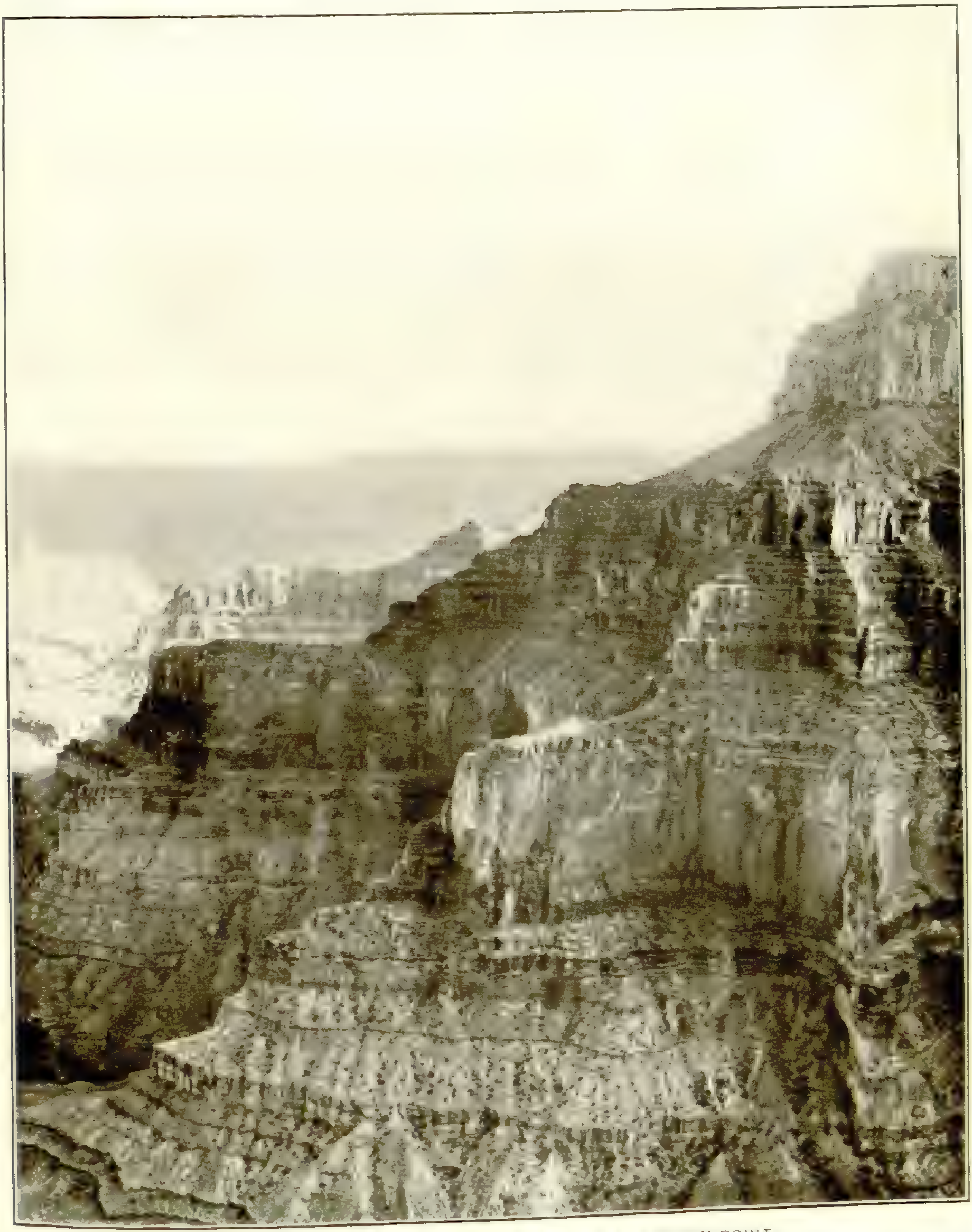
NORTH SIDE OF GRAND CANYON AS VIEWED BY TELESCOPE FROM EL TOVAR HOTEL.

G, Granite and gneiss; U, sandstone, red shale, and limestone (Unkar); T, sandstone of Tonto Platform; Sh, shale of Tonto group lying directly on quartzite of Unkar; R, limestone (Redwall); S, red sandstone and shale (Supai); C, gray sandstone (Coconino); K, limestone (Kaibab). The Redwall butte in center is Cheops Pyramid. Beyond it are Buddha and Manu temples. The background is the Kaibab Plateau.



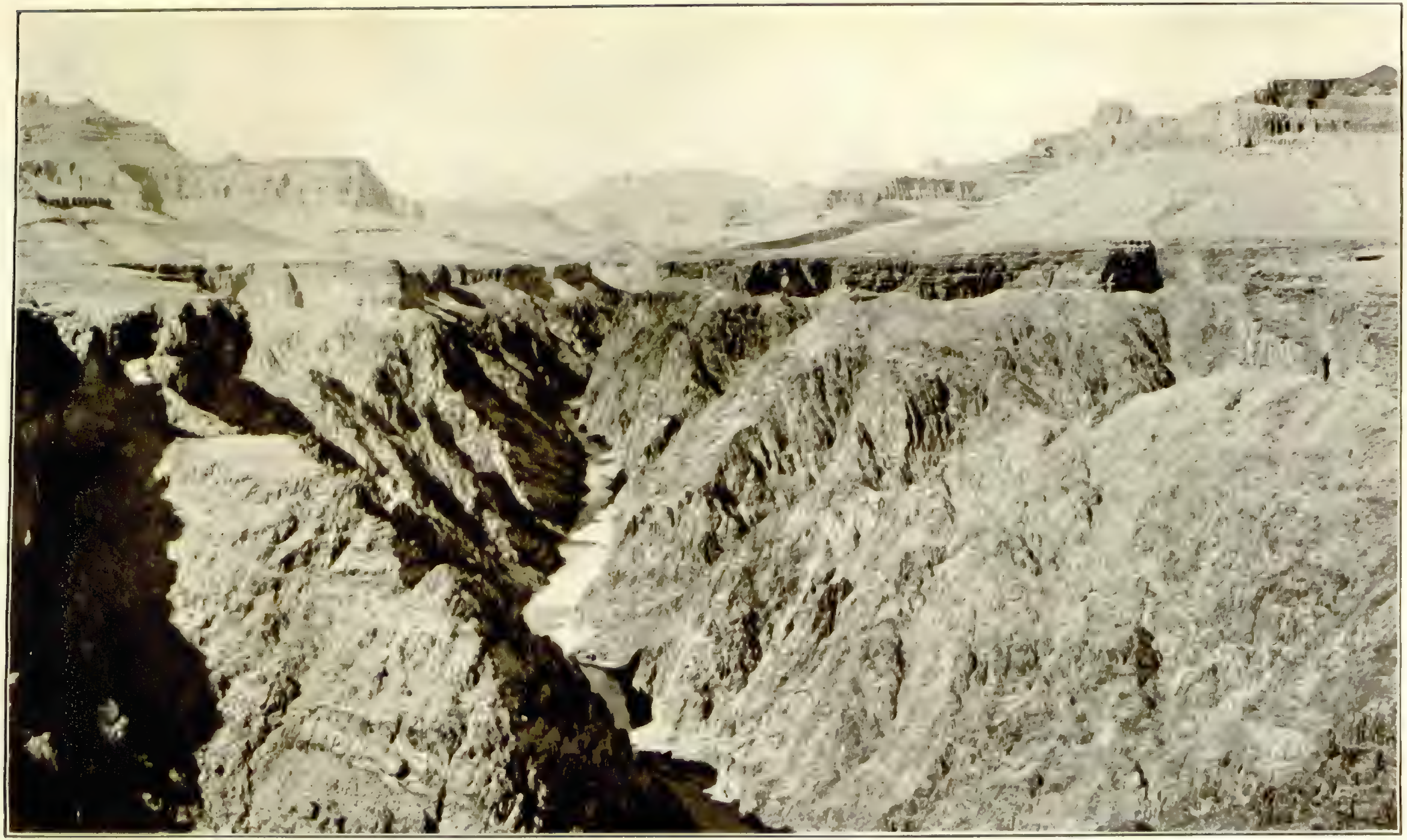
VIEW NORTHEASTWARD ACROSS THE GRAND CANYON FROM ZUNI POINT, EAST OF GRANDVIEW POINT.

The lower slopes are red shales, limestones, sandstones, and marls of Unkar group, dipping east and overlain unconformably by Tonto sandstone and shales of Tonto group at T; R, Redwall limestone; S, red beds of Supai formation; C, gray sandstone (Coconino); K, Kaibab limestone. Painted Desert in the distance.



SOUTH WALL OF GRAND CANYON EAST OF GRANDVIEW POINT.

View eastward. K, Kaibab limestone; C, base of gray sandstone (Coconino) on 1,100 feet of red shale and red sandstone (Supai) extending to top of Redwall limestone at D; R, top limestone of Tonto group.



THE GRANITE GORGE IN THE GRAND CANYON, NORTHWEST OF GRANDVIEW POINT.

Depth, 1,000 feet. Shelf of basal sandstone of Tonto group on sides; shale slopes above. R, limestone (Redwall); S, red sandstone (Supai). Shiva Temple in middle distance; Zoroaster Temple to right.

Local features.

A fairly complete idea of the Grand Canyon can be obtained by observation for a few hours from the rim near the hotels. It is much more satisfactory, however, to go to Hopi and Yavapai points and down to the river, or at least to the Tonto Platform. A visit to Grandview Point (Pls. XXXI and XXXII) adds greatly to the completeness of the trip, and

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separation is effected by organisms of various kinds as well as by chemical reactions not connected with life. This deep submergence was succeeded by shallow water in which the red muds and sands now represented by the Supai formation were laid down to a thickness of a thousand feet or more. Where these sediments came from and the conditions under which they were deposited are not known, but undoubtedly they were derived from land surfaces not far away, where granites, limestones, and other rocks were decomposing and yielding red muddy sediments to streams flowing out across the area of Supai deposition.

The change to the deposition of the Coconino beds was a very decided one, for the coarse gray Coconino sandstone usually lies directly on the soft red shale at the top of the Supai formation. The sand of which it is formed was laid down on beaches and in places where there were strong currents, for the grains are clean and light colored and the extensive cross-bedding (see Pl. XXIX, *B*, p. 119) indicates that there were vigorous currents in various directions. Such a deposit usually accumulates rapidly, so probably the 300 feet of sandstone represents a relatively short space of geologic time.

This epoch was terminated abruptly by deeper submergence due to a long-continued subsidence of the region, and in the extensive sea thus formed was laid down the thick deposit of calcium car-

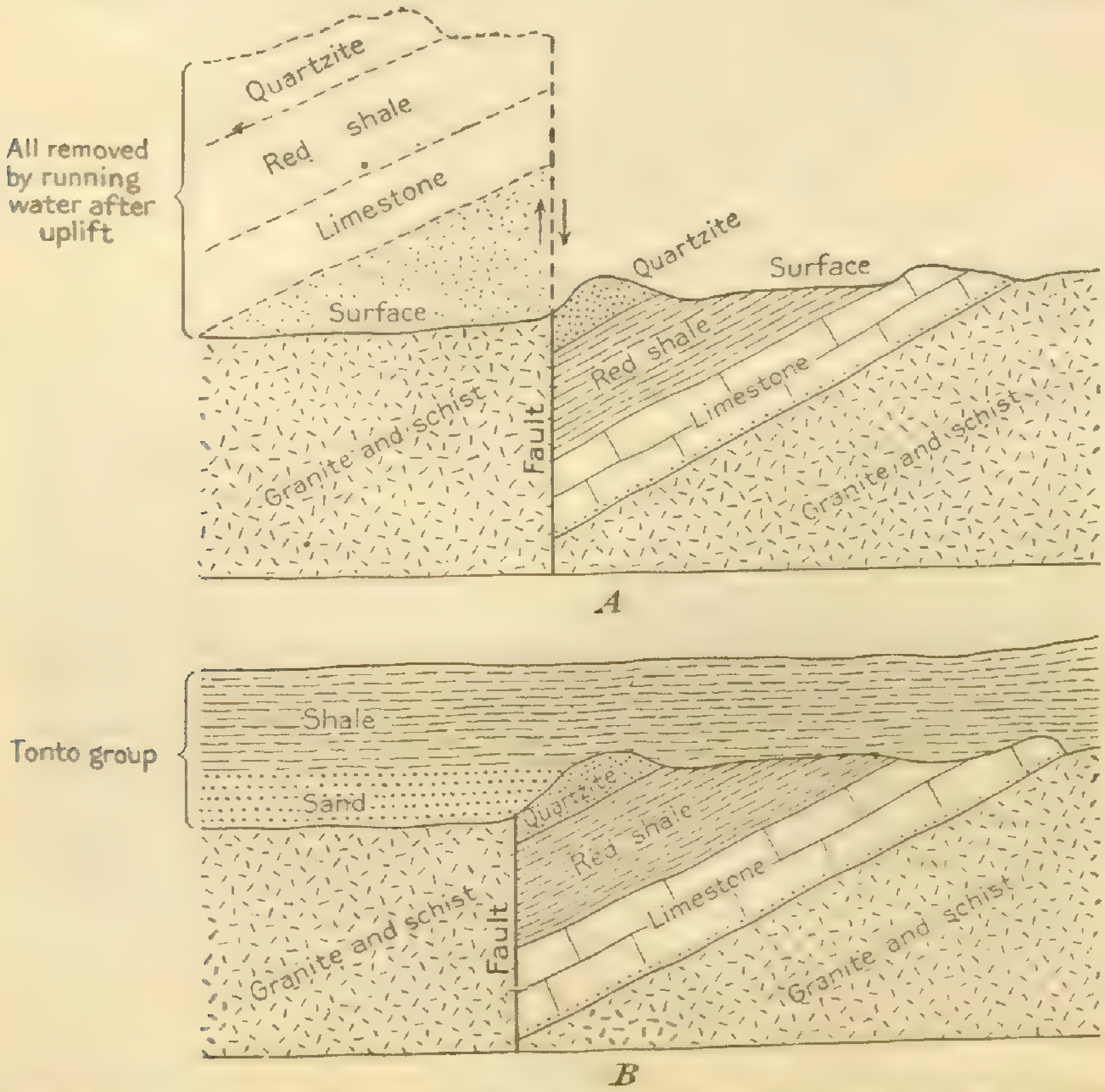

FIGURE 28.—Ideal sections of faulted blocks of Unkar rocks in Grand Canyon, Ariz. *A*, Uplifted blocks that have been removed by erosion; *B*, rocks of Tonto group deposited on surface of Unkar group and granite.

the Hermit trail is very interesting. The descent down the trails to the river is especially helpful in affording a sense of the scale of the canyon and giving opportunity to inspect the rocks at close range. There is neither difficulty nor danger in the journey. The Bright Angel trail descends at El Tovar by a great series of zigzags following the course of a very old Indian footpath. For the first 700 feet it goes down the irregular ledges of Kaibab limestone, the base of which is reached at the entrance to a small tunnel through which the trail passes. At this place there is a fault by which the rocks to the west are lifted 125 feet higher than they are to the east. The plane of this fault is at the entrance to the tunnel. The relations are shown in figure 29.

The character of this massive cross-bedded rock is well shown in the cliff just west of the fault. Next below are red shales and red sandstones of the Supai formation, 1,100 feet thick, extending to the top of a cliff of Redwall limestone, 550 feet thick, down which the trail winds in a tortuous course. Thence the trail goes down slopes of shale of the Tonto group to the Indian Gardens, where a spring has made an oasis formerly utilized by Indians. Not far beyond is the platform or broad terrace caused by the basal sandstone of the Tonto group making a wide shelf through which the main gorge is cut 1,000 feet deep into the granite. (See Pl. XXXIII.) On the north side of the river is a great mass of dark sandstone, red shale, and limestone of the Unkar group, overlain by shale of the Tonto group farther back. These Unkar rocks are twisted and faulted but in general dip to the north at a moderate angle, as shown in figure 30 (p. 130).

From Hopi and Yavapai points, which are within 2 miles of the hotels, there are superb views up and down the river, showing a great succession of cliffs, promontories, and buttes in endless variety of form, with geologic relations most clearly exhibited. They are all shown on sheet 19A (p. 130). The cross sections in figure 30 show the general

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bonate now represented by the Kaibab limestone. The numerous shells in this deposit are those of animals that lived in the sea. The water probably was moderately deep, and it is believed that the limy sediments accumulated very slowly during a long period of gradual subsidence. The time required for the accumulation of 700 feet of sediments of this sort must have been very great, surely several million years; it continued for a large part if not entirely through the later portion of the Carboniferous period.

Upon the Kaibab limestone, which constitutes the present surface of the high plateau, there were deposited many thousand feet of sandstones and other rocks through Permian, Mesozoic, and Cenozoic time. These rocks originally covered the present plateau area but were in greater part removed by erosion before the beginning of the excavation of the canyon. Remnants of them may be seen in Red Butte, not far south of El Tovar; in Cedar Mountain, far to the east on the Coconino Plateau; and in the great line of the Vermilion Cliffs, far to the north, beyond the Kaibab Plateau. Their removal required several million years, and most of it was completed before the excavation of the present canyon was begun.

MAJOR J. W. POWELL AND THE BOATS IN WHICH HE MADE THE TRIP DOWN THE GRAND CANYON.

The view is in Marble Canyon.

features. From Grandview Point there is an extended view to the east and northeast, to the point where the canyon of the Little Colorado comes in. A wide area in the lower part of the canyon in this district is occupied by rocks of the Chuar and Unkar groups.

If the observer is impressed by the long time required for the excavation of the Grand Canyon in the slowly rising plateau, let him consider also the time required for the accumulation of the sediments in the many thousands of feet of rocks in the canyon walls. He may reflect also on their vast area, for they underlie not only the plateau he sees, but also a large part of our continent. An inch of the limestone required many years for its deposition, the shale was mud brought from distant hills by turbid streams and spread in thin layers, and the sands were deposited by streams or spread on beaches far from their original sources in the rocky ledges of the higher lands. It should be noted also that in the canyon section are lacking the rocks which represent a large part of geologic time in other regions. A very long time was also required for the deposition of 12,000 feet of the Unkar and Chuar groups and the planation of their surface and of the granite surface on which they lie. Probably this required as

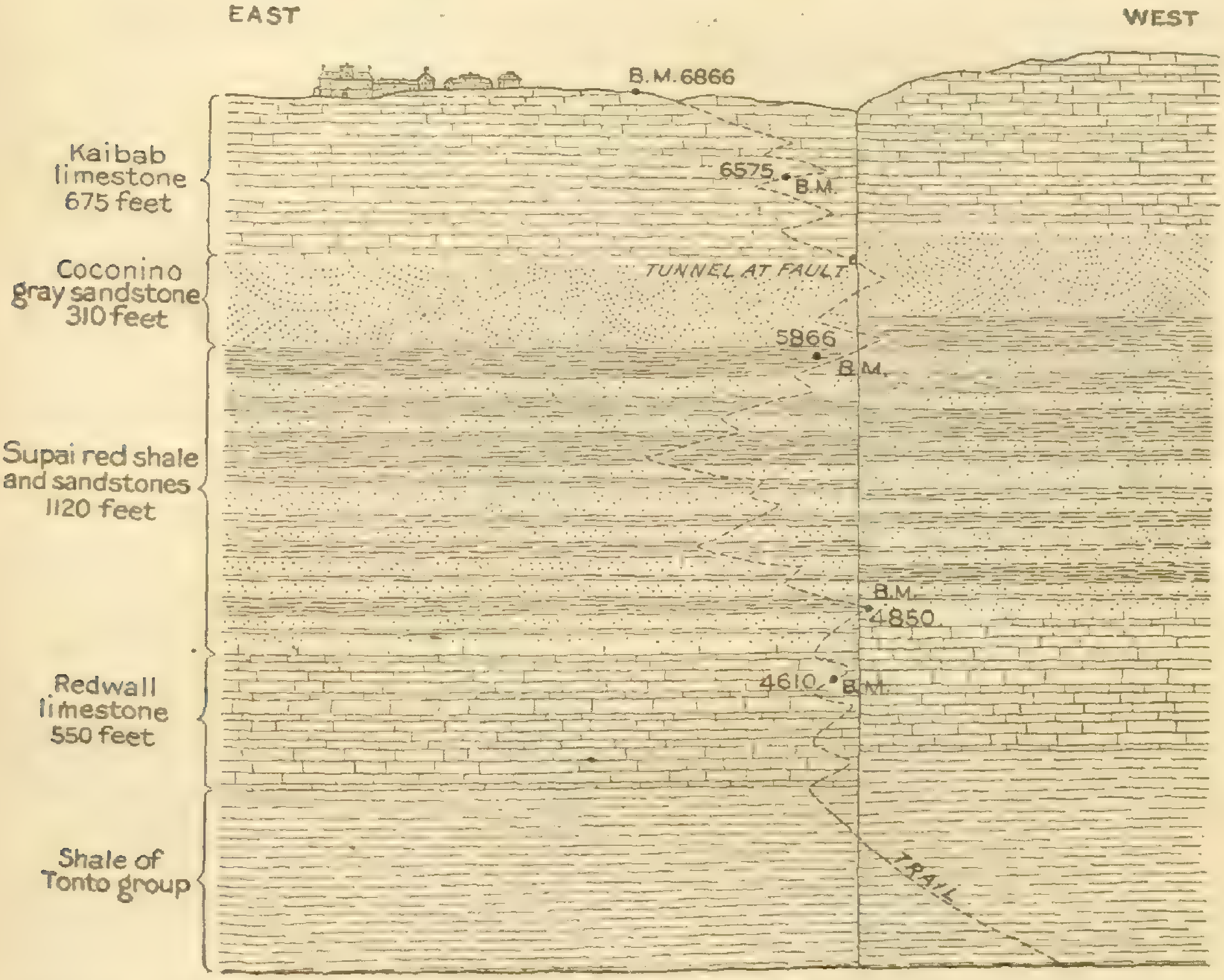

EAST
WEST
B.M.6866
Kaibab limestone 675 feet
6575 B.M.
Coconino gray sandstone 310 feet
TUNNEL AT FAULT
5866 B.M.
Supai red shale and sandstones 1120 feet
B.M. 4850
Redwall limestone 550 feet
4610 B.M.
Shale of Tonto group
TRAIL

FIGURE 29.—Section of rocks exposed on Bright Angel trail, Grand Canyon, Ariz., showing relations of fault, and the position of bench marks of the United States Geological Survey (brass caps with elevation above sea level). This fault and the pile of débris from the beds broken by it has made a trail practicable at this place, for generally the 300-foot cliff of Coconino sandstone is inaccessible.

much time as is represented by the horizontal rocks in the upper and middle canyon slopes. Finally, a great period of time before all this is represented by the granites and associated rocks exposed in the inner gorge. They underlie the plateau and present a chapter in the earliest known history of the crust of our earth.

The first white men to see the Grand Canyon were Cárdenas and his 12 companions, who were guided there by Hopi Indians from Tusayan. Cárdenas was sent by Coronado to find the wonderful river of which DeTovarhad heard from the Indians. He remained four days on the rim at some point now unknown, looking in vain for a way to descend. It is always interesting to recall the heroic trip made by Maj. J. W. Powell down the Grand Canyon in small boats when practically nothing was known of its course or character. His journey began at Green River, Wyo., May 24, 1869, and was notably successful. A portrait of Maj. Powell and a view of his boats are given in Plate XXXIV (p. 128).

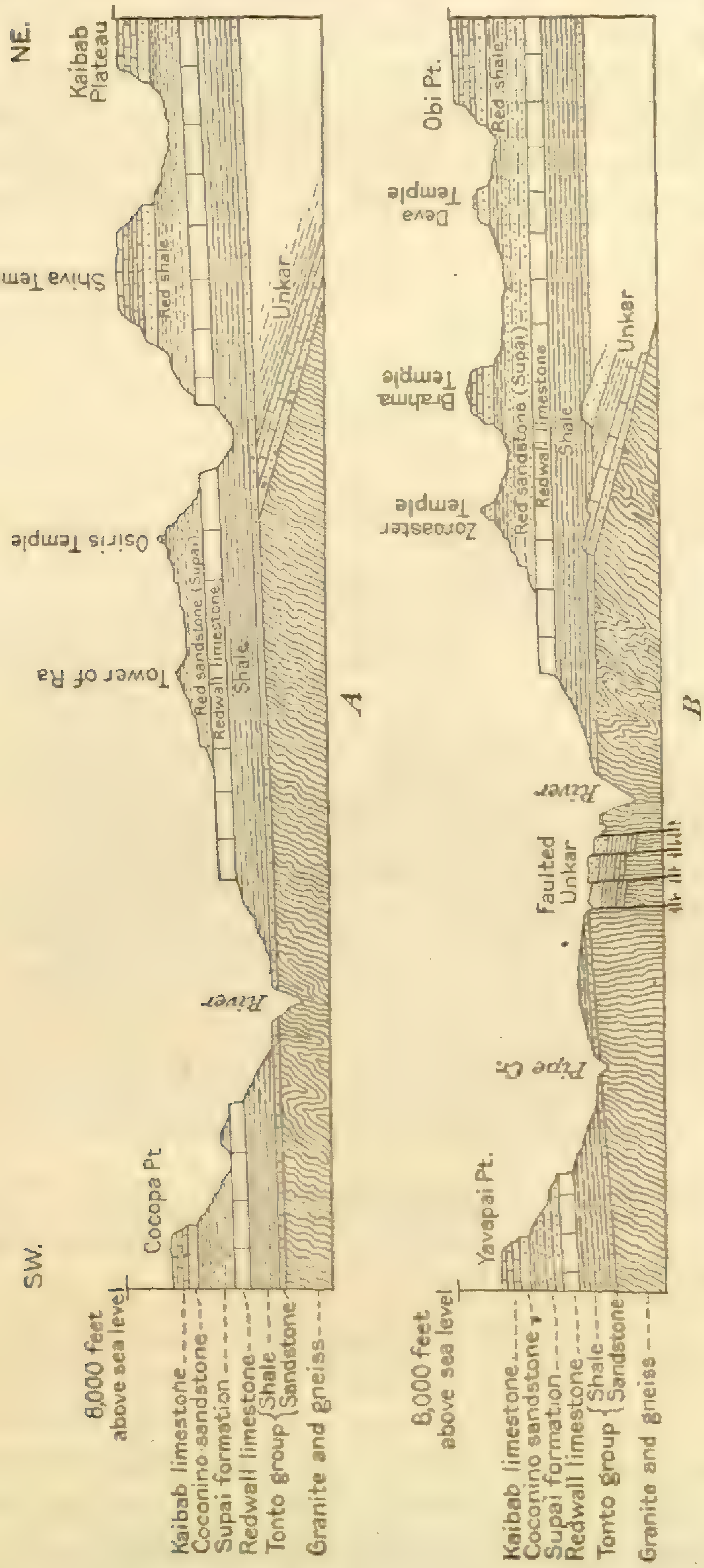


FIGURE 30.—Sections across Grand Canyon, Ariz., looking west. *A*, From Cocopa Point through Tower of Ra, Osiris and Shiva temples to Kaibab Plateau at Tyo Point; *B*, from Yavapai Point through Zoroaster, Brahma, and Deva temples to Kaibab Plateau at Obi Point.

The hotel at Grand Canyon was named for Pedro de Tovar, who was ensign general of Coronado's expedition. He and most of his associates were men of high social position, De Tovar's father being the

GEOLOGIC AND TOPOGRAPHIC MAP
SANTA FE ROUTE
From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atchison Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

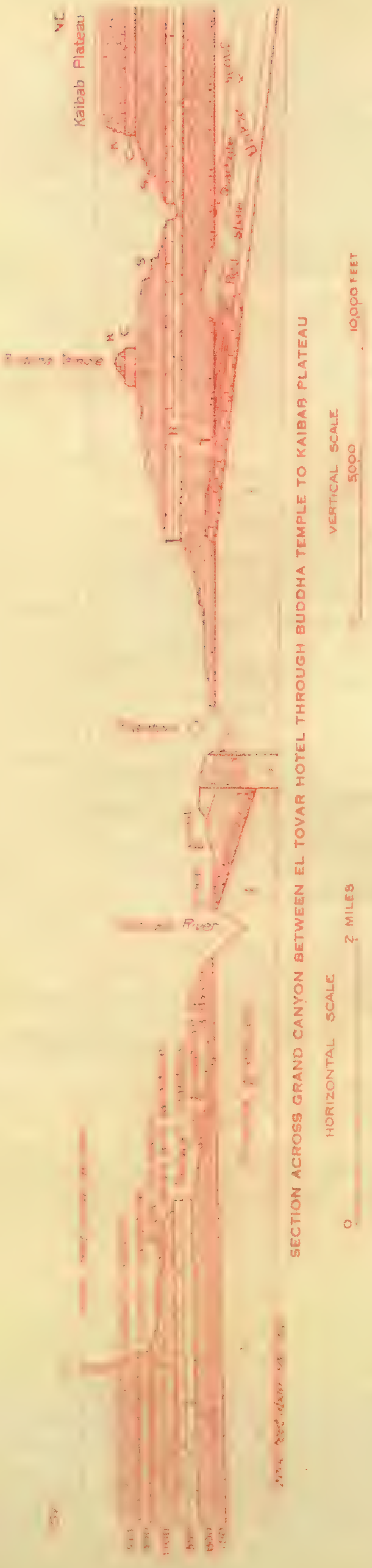
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist
R. B. Marshall, Chief Geographer

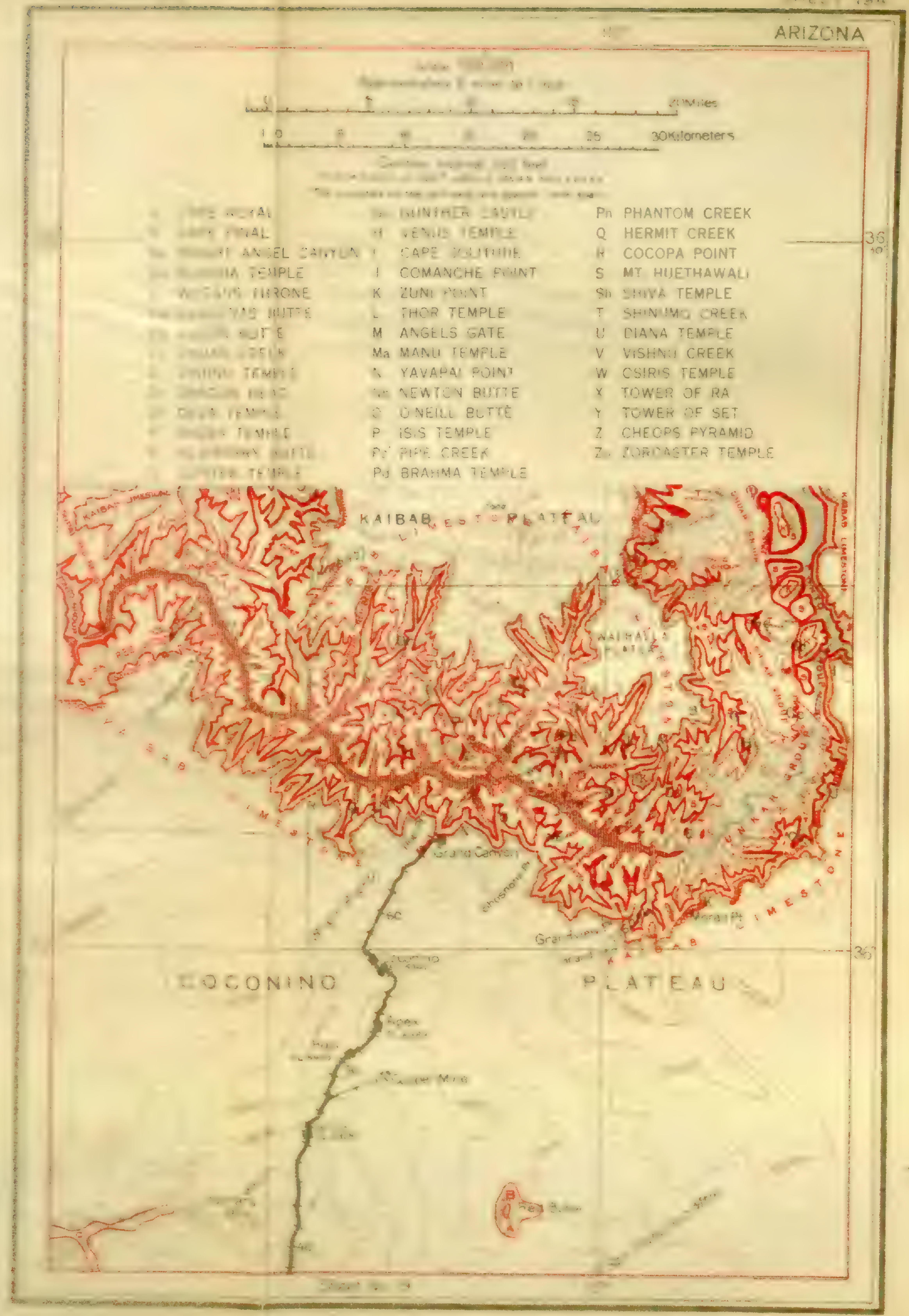
1915

Each quadrangle shown on the map with a name in parentheses in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name

EXPLANATION

			Thickness in feet	
A	Lava flow, basalt			Quaternary or Tertiary
B	Conglomerate Sandstone, red	Shinarump Moencopie formation	60 600	Triassic Carboniferous (Permian ?)
K	Limestone, massive, light colored	Kaibab	750	Carboniferous (Pennsylvanian)
C	Sandstone, gray, cross-bedded	Coconino	300	
S	Sandstone and shale, all red	Supai formation	1100	
R	Limestone, massive	Redwall	550	Carboniferous (Pennsylvanian and Mississippian
T	Shale Sandstone	Tonto group	900	Cambrian
H	[illegible]	[illegible]	[illegible]	
G	[illegible]	[illegible]	[illegible]	[illegible]
J	[illegible]			


Kaibab Plateau
Buddha Temple
SECTION ACROSS GRAND CANYON BETWEEN EL TOVAR HOTEL THROUGH BUDDHA TEMPLE TO KAIBAB PLATEAU
VERTICAL SCALE
0
5000
10,000 FEET
HORIZONTAL SCALE
0
2 MILES



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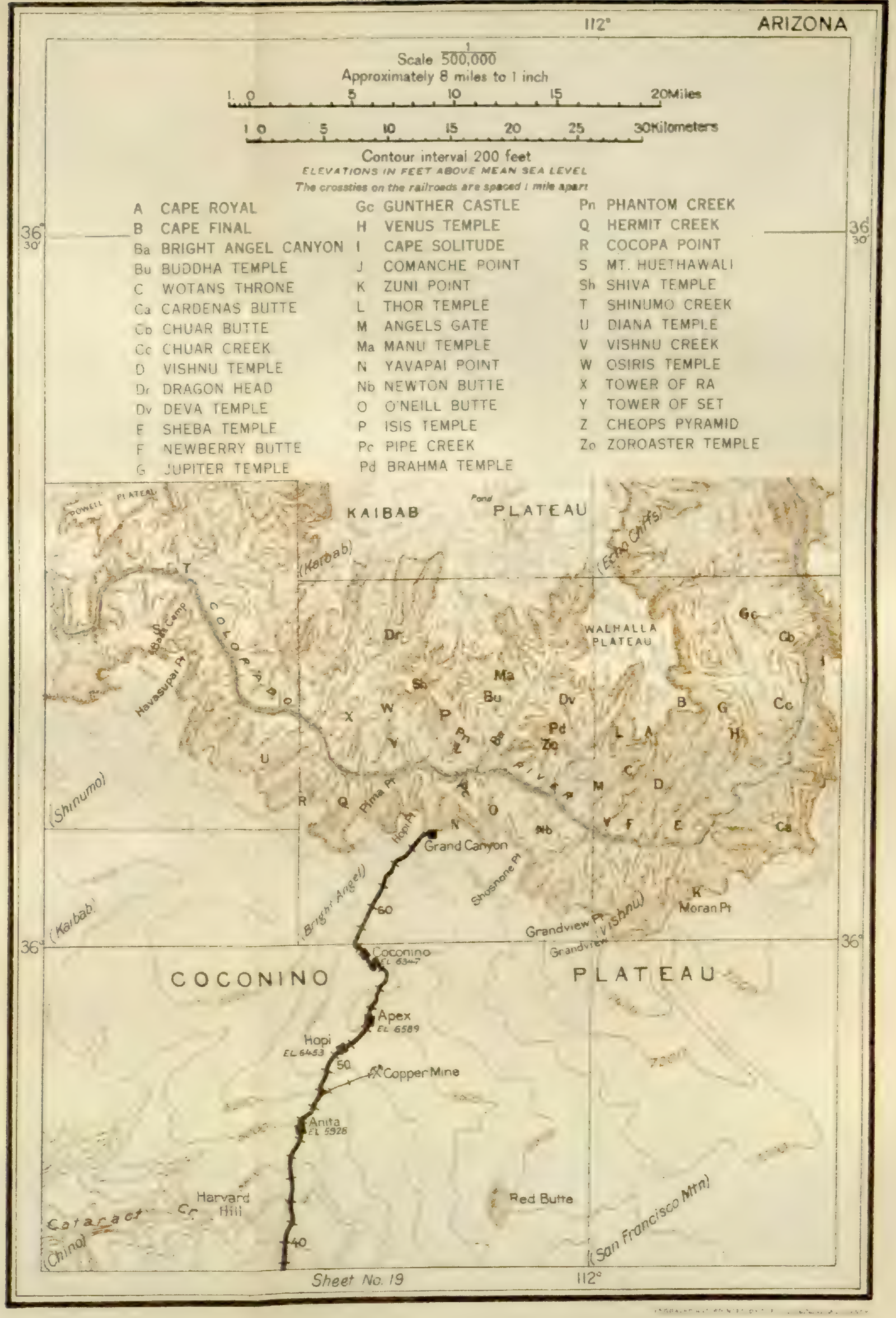
David White, Chief Geologist   R. B. Marshall, Chief Geographer
1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.



A	CAPE ROYAL	Gc	GUNTHER CASTLE	Pn	PHANTOM CREEK
B	CAPE FINAL	H	VENUS TEMPLE	Q	HERMIT CREEK
Ba	BRIGHT ANGEL CANYON	I	CAPE SOLITUDE	R	COCOPA POINT
Bu	BUDDHA TEMPLE	J	COMANCHE POINT	S	MT. HUETHAWALI
C	WOTANS THRONE	K	ZUNI POINT	Sh	SHIVA TEMPLE
Ca	CARDENAS BUTTE	L	THOR TEMPLE	T	SHINUMO CREEK
Cb	CHUAR BUTTE	M	ANGELS GATE	U	DIANA TEMPLE
Cc	CHUAR CREEK	Ma	MANU TEMPLE	V	VISHNU CREEK
D	VISHNU TEMPLE	N	YAVAPAI POINT	W	OSIRIS TEMPLE
Dr	DRAGON HEAD	Nb	NEWTON BUTTE	X	TOWER OF RA
Dv	DEVA TEMPLE	O	O'NEILL BUTTE	Y	TOWER OF SET
E	SHEBA TEMPLE	P	ISIS TEMPLE	Z	CHEOPS PYRAMID
F	NEWBERRY BUTTE	Pc	PIPE CREEK	Zo	ZOROASTER TEMPLE
G	JUPITER TEMPLE	Pd	BRAHMA TEMPLE		

guardian and lord high steward of Doña Juana, the daughter of King Ferdinand and Queen Isabella, who married Philip the Second. On no other exploration were there so many distinguished men as accompanied Coronado on his dangerous journey from Mexico into this unknown land.

MAIN LINE WEST OF WILLIAMS.

From Williams (see sheet 19, p. 122) westward for some distance Bill Williams Mountain is a prominent feature south of the railway. Cinder cones are in view to the north, and one of considerable size also lies at the foot of Bill Williams Mountain a short distance south of the tracks. After passing Supai siding, 3 miles west of Williams, the train begins the long descent from the high plateau of lava and Kaibab limestone. From Supai to Corva a new line with an easier grade has been built for the eastbound trains. The lava (basalt) extends to the edge of the plateau and for a considerable distance down its western slope, but the deeper canyons in the slope cut through into the Kaibab limestone.

There are deep cuts in the basalt at the entrance to Johnson Canyon. This gorge affords an advantageous line of descent for the westbound trains and exhibits many features of interesting geology and attractive scenery.

Halfway between mileposts 388 and 389 the Kaibab limestone appears under the lava, and the train passes through a tunnel in the limestone with the lava cap not far above. On leaving the tunnel it goes over a long trestle, below which are many cliffs of the limestone, most of them with a capping of lava. In the deep canyon to the south are some sink holes in the limestone, known as the Bottomless Pits, into which the water disappears when there has been sufficient rain to develop a stream in the canyon. They are similar in character and origin to the pits described on page 117.

A short distance beyond milepost 390 the lava descends over the limestone ledges to a level somewhat below that of the bottom of Johnson Canyon, and for several miles west from this place it constitutes a broad bench that extends for some distance north and south of the canyon. From these relations it appears that the outflow of lava, probably issuing from a vent on top of the plateau west of Williams, flowed westward over the plateau surface and down its western slope. The canyons have been eroded by streams since the time of this eruption, and some of the deeper ones have been cut through the lava into the underlying limestone. In part of the slope a few miles south of Johnson Canyon the grade down which the lava flowed was very steep, and at this place the igneous rock is very much broken where it cascaded over the limestone ledges. This outflow occurred many thousand years ago, as much erosion has taken place since; but compared with most of the other events in geologic history it was very recent.

Fairview.

Elevation 5,935 feet.
Kansas City 1,315 miles.

The broad bench made by the lava at the lower level just mentioned is well exhibited near Corva, where the eastbound track joins the old line. Fairview is a siding on this bench. A short distance beyond Fairview is a cut in a low cinder cone that shows that there was a volcanic vent at this place from which may have issued some of the lava on the lower bench. Two miles farther west is a long cut in cinders, including numerous bombs of various sizes.

About 4 miles west of Fairview there are excellent views of the edge of the high plateau extending off northwestward. The white ledges of Kaibab limestone appear in places, capped by the black lava at the summit of the plateau and underlain by the Coconino sandstone extending down some distance to the lava-covered bench above mentioned. The extension of the cliff to the southeast is also visible but less plainly.

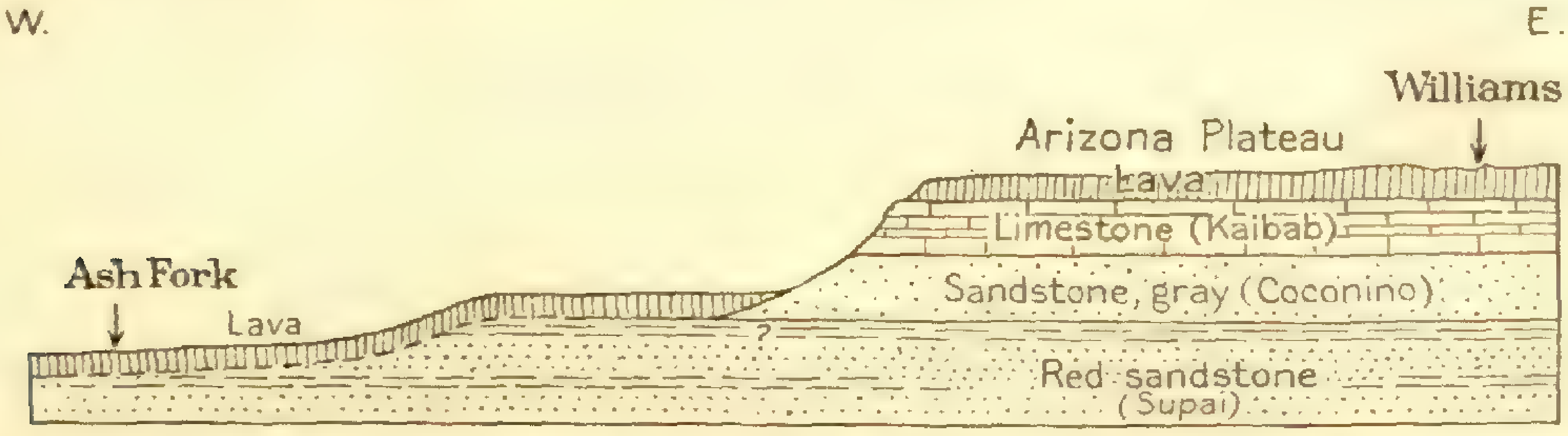


FIGURE 31.—Section of the west slope of the Arizona Plateau between Williams and Ash Fork, Ariz., looking north.

At milepost 399, 5 miles west of Fairview, there are long cuts in cinders with bombs, beyond which the railway descends westward in long sweeping curves that extend nearly to Ash Fork. At the foot of this down grade there is a wide valley trending northwest and occupied largely by lava which has flowed from many local orifices, in most places marked by cinder cones. A section showing the general relations in the descent of the great escarpment east of Ash Fork is given in figure 31.

This descent is the first in a series of great westward-facing steps formed by the thick pile of sedimentary rocks constituting the plateau region of western Arizona. These rocks are shown in cross section in the Grand Canyon, and in the westbound journey the traveler sees, beyond Williams, the same succession that is revealed in the descent into the canyon from the rim. The first step is the western edge of the Kaibab limestone which caps the plateau and finally terminates in the Aubrey Cliffs. The second great step consists of the Grand Wash escarpment, Music Mountain, and the cliffs south of Peach Springs, in which the western edges of the lower part of the Redwall limestone and the underlying shales and sandstones are presented at the termination of the plateau province.

Ash Fork.

Elevation 5,144 feet.
Population 517.*
Kansas City 1,322 miles.

Ash Fork owes its existence mainly to the fact that it is the junction of the branch railway to Prescott, 57 miles south, and Phoenix, 194 miles south. Many of the trains stop here for meals at the Escalante, a hotel named in memory of Francisco S. Vélez Escalante, a Spanish missionary who traveled through this country in 1775. Ash Fork has an exceptionally good climate and is ambitious to become a winter resort.

A mile west of Ash Fork, in a low cinder cone just south of the railway, there is a large pit from which material is excavated for ballast. The exposed face, 50 feet high, exhibits the relations of the cinders with many included bombs and more or less admixture of volcanic ash. For some distance westward the train passes over a plain of lava which floors the wide valley in which Ash Fork is situated. To the west rises the prominent peak known as Picacho (pee-cah′tcho) Butte, and to the northwest Mount Floyd, both large masses of the older igneous rock similar to that in the San Francisco Mountains and Bill Williams Mountain.

A mile or more beyond Pineveta the eastbound tracks diverge to the north, crossing over the old line, which is reserved for westbound traffic and which climbs out of this valley up the steep grade to the west by numerous large curves, including one notable loop known as Horseshoe Bend. On these loops there are excellent views to the east, in which Bill Williams Mountain is a prominent feature, rising far above the relatively even sky line at the crest of the high plateau. Farther east on the horizon the peaks of the San Francisco Mountains are conspicuous, though somewhat dwarfed by distance. The slope on which the track rises consists of lava (basalt) and toward its higher portion there are many junipers.

Crookton.

Elevation 5,691 feet.
Kansas City 1,339 miles.

Near Crookton, one-tenth of a mile west of milepost 419, where the summit of this grade is reached, the two tracks come together again, with that for the westbound traffic on the right-hand side. The summit consists of lava (basalt) and this rock extends along both sides of this divide and down the west slope. Picacho Butte is a prominent feature to the south and Mount Floyd and the surrounding peaks rise about 8 miles to the north.

From Crookton to Seligman there is a long descent of 450 feet on lava-covered slopes into the valley of Chino (chee′no) Wash. The lava lies on the sloping surface of the limestone which caps the Aubrey Cliffs to the north. The interruption in these cliffs in this portion of their course was a fortunate thing for the construction of the railway. If they had extended continuously across the country at a height of 1,200 feet, as to the north and south, there would have been great difficulty in building the railway down them. The break in their continuity was developed by erosion or faulting prior to the time of the volcanic eruptions, and now the sloping surface is covered by the extensive sheet of lava extending from Crookton to Seligman and beyond.

Seligman.
Elevation 5,242 feet.
Population 338.*
Kansas City 1,350 miles.

Seligman, being a railway division point, is sustained largely by the railway interests, together with trade from scattered ranches in some of the adjoining valleys. The railway time changes here from mountain to Pacific time, one hour earlier. Formerly the branch line to Phoenix joined the main line at this place, following a relatively easy grade up Chino Valley. It was changed to shorten the distance from Phoenix to the East. There is a road from Seligman north 67 miles to Cataract Canyon, a branch of Grand Canyon, which has high red walls and several picturesque waterfalls. Here live the Havasu (Supai) Indians, who cultivate a few acres of rich land by the water from the great springs that form Cataract Creek.

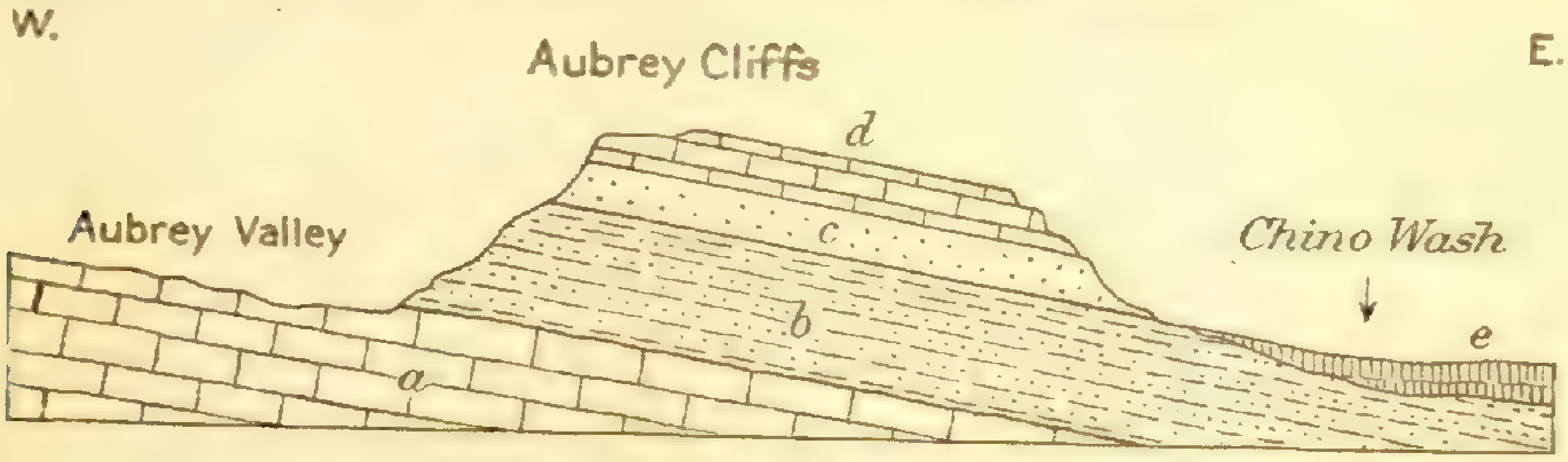
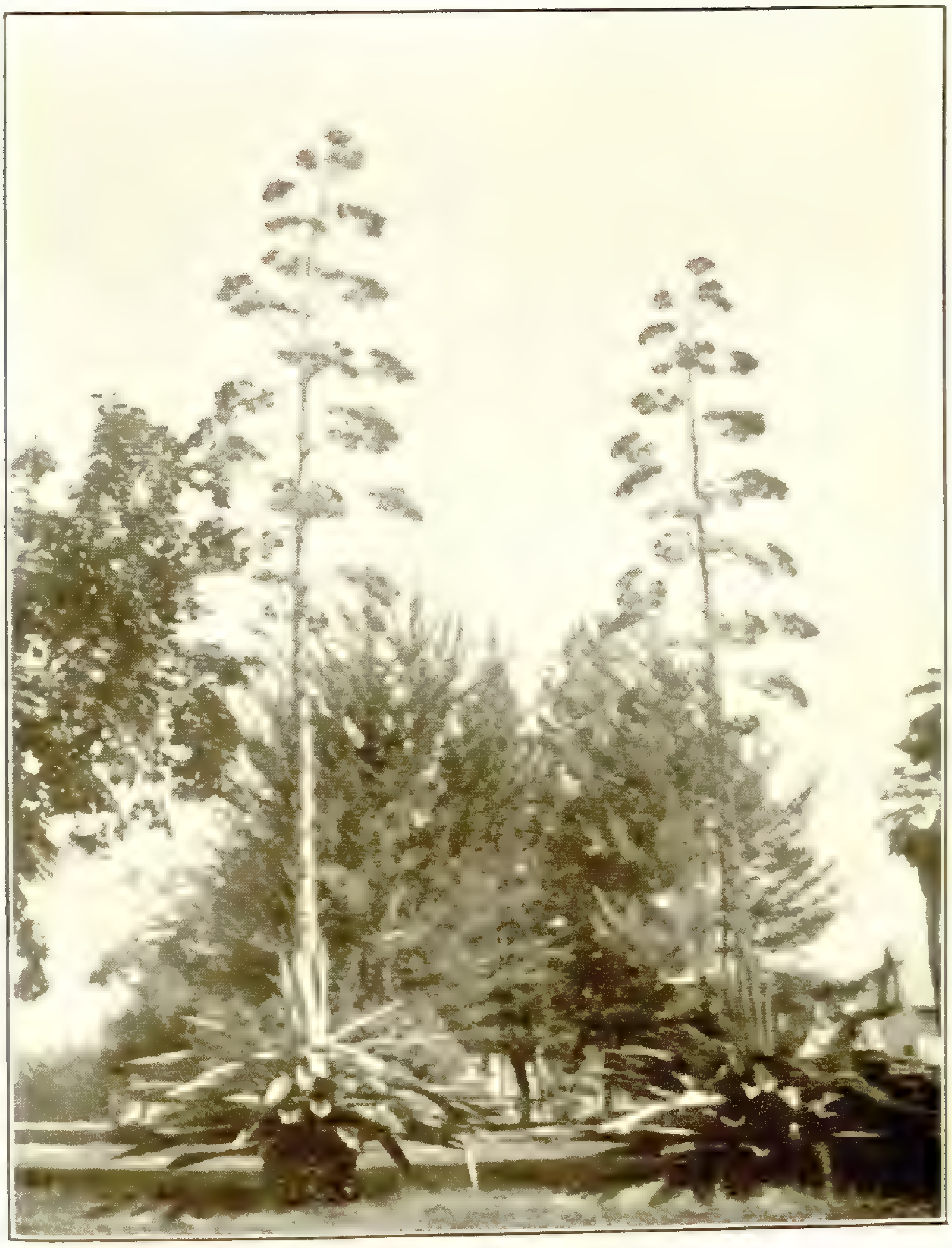


FIGURE 32.—Section through Aubrey Cliffs, northwest of Seligman, Ariz., looking north. *a*, Limestone (Redwall); *b*, red sandstone and shale (Supai); *c*, gray sandstone (Coconino); *d*, limestone (Kaibab); *e*, lava.

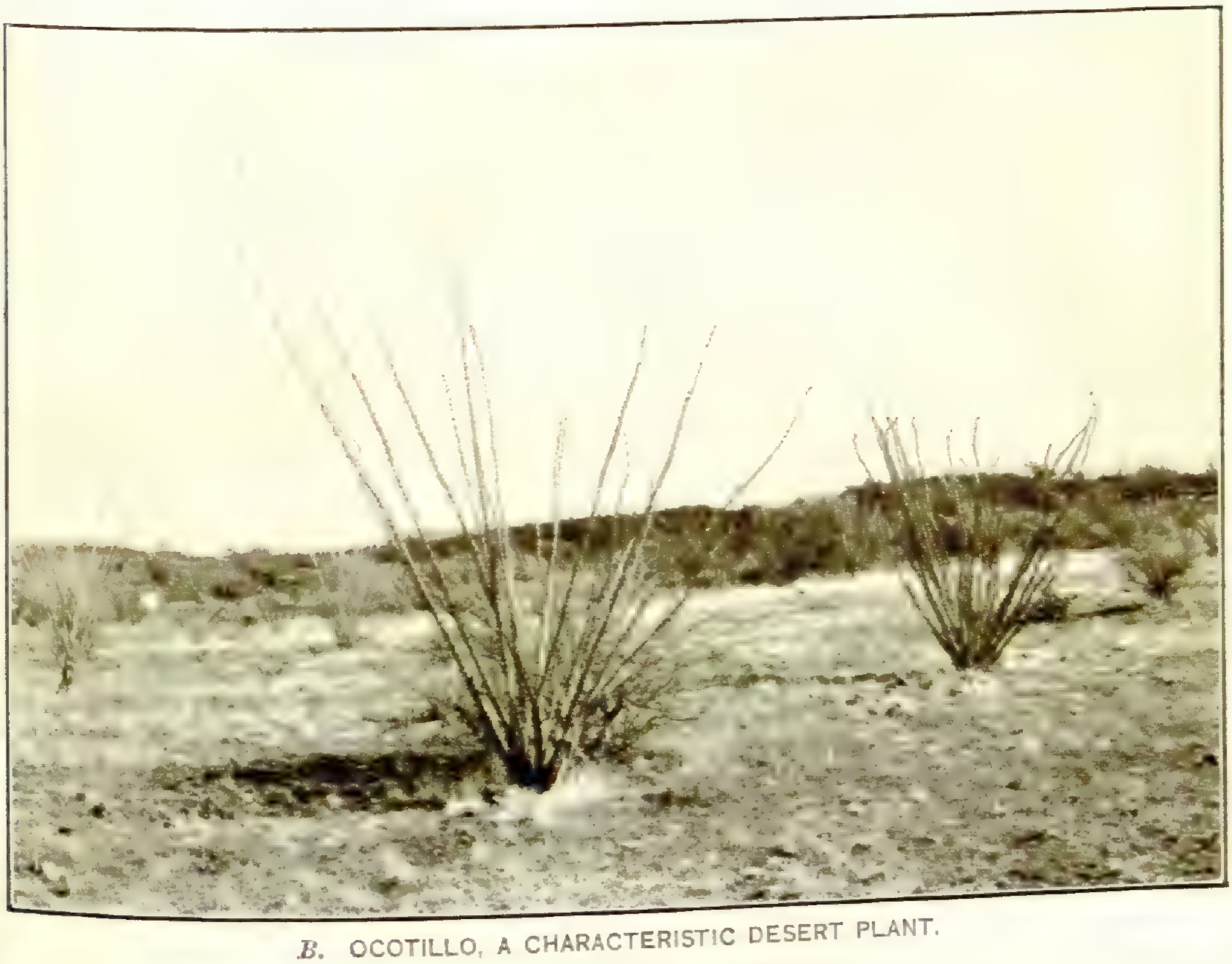
Railway cuts a short distance west of Seligman show the red sandstone and shale of the Supai formation lying on Redwall limestone. Three miles west of Seligman, near Chino, high cliffs of red sandstone (Supai formation) are conspicuous along the northeast side of the railway. They extend along the lower slope of the Aubrey Cliffs, which continue as a long, high wall far to the north. Above the red sandstones in these cliffs are ledges of light-gray sandstone (Coconino), which is softer and less conspicuous here than in the walls of the Grand Canyon. At the top of the cliff are light-colored ledges of the cherty Kaibab limestone, forming a plateau that slopes somewhat to the east. The relations in this cliff are shown in figure 32.

The Aubrey Cliffs extend for many miles across the plateau region on both sides of the Grand Canyon. As explained above, they are caused by the western edge of the great sheet of limestone that caps the Arizona Plateau. The depression at their foot, here known as Aubrey Valley, is followed by the railway for some distance to the northwest, past Audley and Pica sidings. The floor of the valley



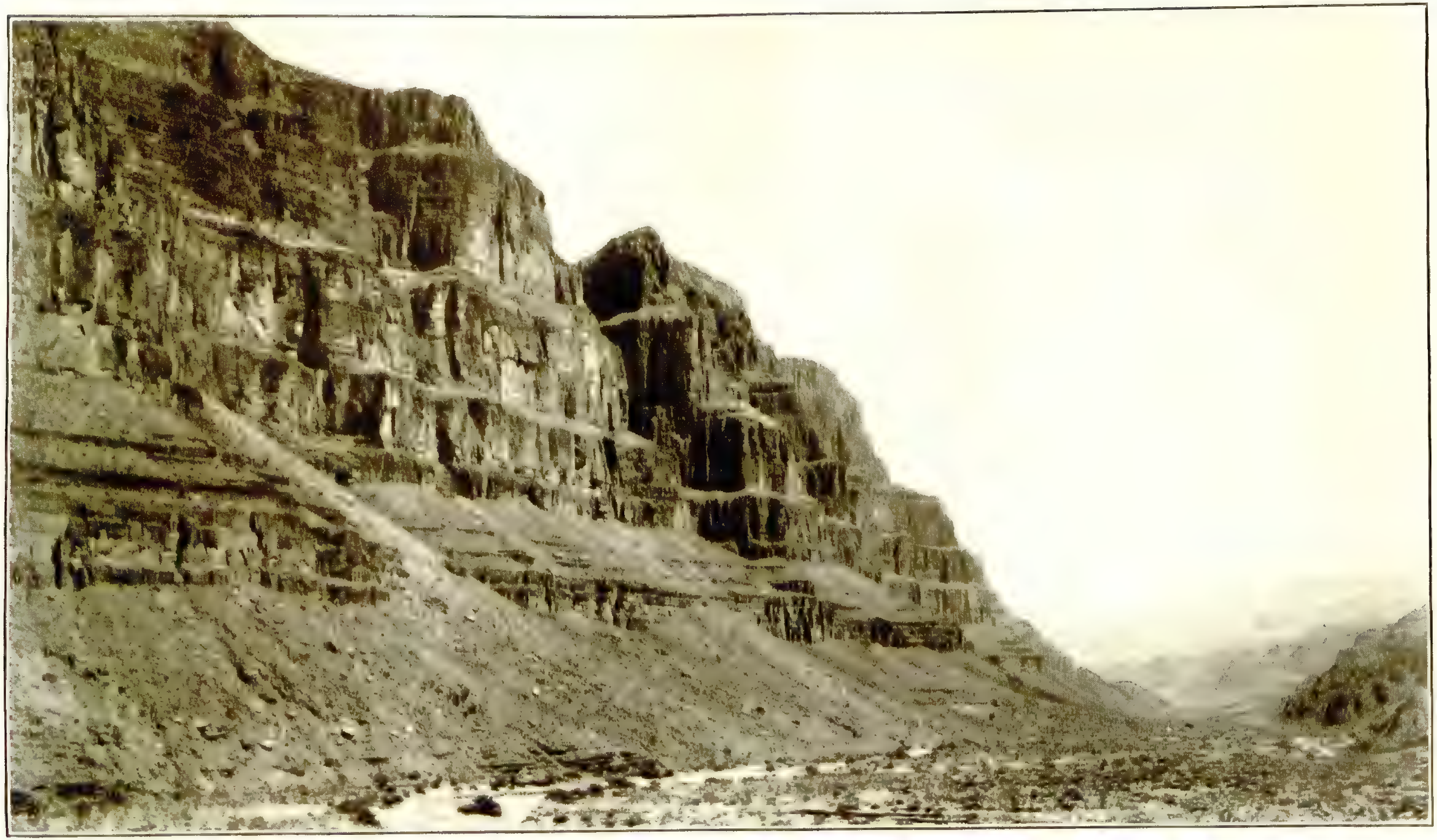
A. MESCAL, OR MAGUEY.

These plants grow at many places on the ridges in western Arizona.



B. OCOTILLO, A CHARACTERISTIC DESERT PLANT.

In the spring it is covered with red flowers.



CLIFFS OF SANDSTONE OF THE TONTO GROUP IN CANYON FOUR MILES NORTH OF PEACH SPRINGS, ARIZ.

Cliffs on north side of Grand Canyon of the Colorado in the distance.

consists in part of the lower red shale of the Supai formation and in part of the upper surface of the Redwall limestone. The railway follows the boundary line between these two formations, in some places on the red shale and in others on the limestone. The Aubrey Cliffs are prominent in the landscape to the east as the train bears away northwestward by rising on the gentle slope of the eastward-dipping beds to the summit of the plateau of Redwall limestone. This plateau is the next "step" in the descent from the great plateau of Arizona, a descent which is begun a short distance west of Williams and continues nearly to Colorado River.

Pica.

Elevation 5,247 feet.
Kansas City 1,367 miles.

At Pica (see sheet 20, p. 138) there are wells 1,100 feet deep sunk on the recommendation of a Government geologist. They furnish water for locomotives and also for a large number of cattle and sheep.

Yampai.

Elevation 5,580 feet.
Kansas City 1,373 miles.

The summit of the slope of Redwall limestone is reached at Yampai, where there are cuts in this limestone. At the summit is a wide pass, west of which the train enters Yampai Canyon, cut in the Redwall limestone to Peach Springs, a distance of about 14 miles. Below Fields siding the walls of the canyon show extensive ledges of the limestone, and at Nelson this rock is quarried to a moderate extent for burning into lime.

Nelson.

Elevation 5,106 feet.
Population 300.*
Kansas City 1,380 miles.

Massive beds of hard limestone, weathering to a light dove-gray color, are highly characteristic of the Redwall in this region, as also in places in the Grand Canyon where the rock is not stained red by wash from the overlying red shale. On some of these limestone walls there may be seen the peculiar mescal plant, or maguey (mah-gay′, *Agave americana*) shown in Plate XXXV, *A*. After several years of growth the plant sends up a tall flower stalk which develops from a cabbage-like heart greatly prized by the Indians, who roast it in small pits in the ground. Its juice is sweet and when fermented and distilled yields the mescal brandy so extensively used in Mexico and the Southwest.

Peach Springs.

Elevation 4,789 feet.
Kansas City 1,387 miles.

Near Peach Springs the Yampai Canyon widens into a valley known as Truxton Wash, which for some distance westward is occupied by a lava flow (basalt) that is well exposed for half a mile or more beyond Cherokee siding. The ridge north of the valley consists of Redwall limestone. On its north side there are canyons descending into the Grand Canyon of the Colorado at a point only 18 miles north of the Peach Springs station. These smaller canyons are cut mainly in sandstone and shales of the Tonto group (see Pl. XXXVI) lying on granite, which is deeply trenched in turn as Colorado River is approached. A fairly good road extends from

Peach Springs to the bank of the Colorado. The walls of the Grand Canyon are not as high here as in the region farther east, yet it still has a deep inner gorge of granite extending up to cliffs and slopes of sandstones and shales of the Tonto group surmounted by high cliffs of Redwall limestone. The escarpment or cliff of Redwall limestone is prominent south of Peach Springs, where it gradually attains a high altitude, and it extends nearly due south for many miles.

Truxton.

Elevation 4,204 feet.
Kansas City 1,399 miles.

From Cherokee nearly to Truxton the valley widens greatly and is floored by gravel and sand washed from the adjacent mountain slopes. At Truxton the valley merges into a gorge in which appears the granite underlying the Tonto group. This granite extends northward to the foot of Music Mountain, a high cliff and peak which is prominently in view 7 miles to the northwest from the vicinity of mileposts 475 and 476. It is the same rock that is exposed in the lower part of the Grand Canyon. Music Mountain is the southwest corner of the Grand Wash Cliffs, of which more can be seen from Antares, 18 miles farther west.

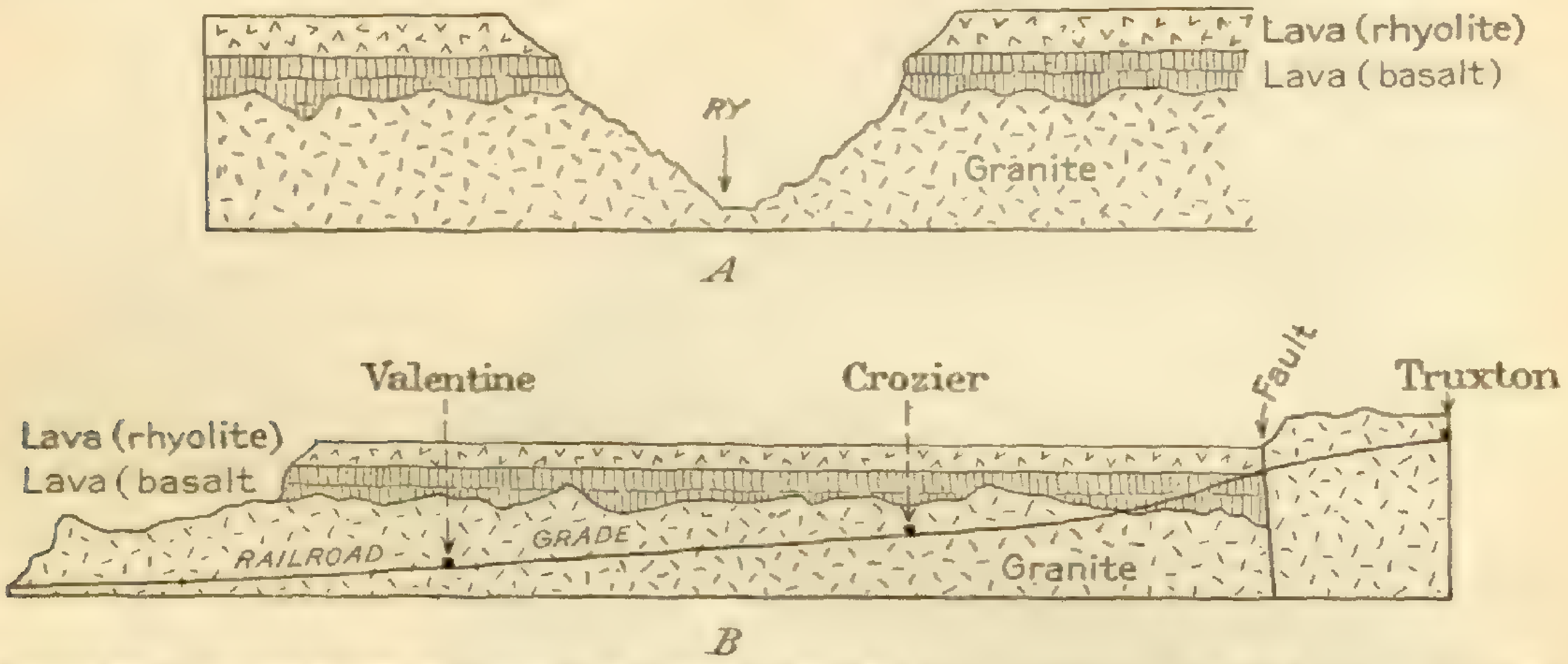


FIGURE 33.—Sections showing relations of granite and lava in canyon of Truxton Wash between Valentine and Truxton, Ariz. *A*, Section across the canyon east of Valentine, looking west; *B*, section along the canyon, looking north.

A short distance west of Truxton there appears to be a great fault crossing the railway, with the uplift on its east side. It is probably the southern extension of the fault extending along the west foot of the Grand Wash Cliffs shown in figure 33. On the west side of this fault the railway passes into a lava field and for some distance follows a narrow canyon in the lava.

Crozier.

Elevation 3,971 feet.
Kansas City 1,402 miles.

On approaching Crozier the train passes below the edge of the lava cap into a gorge in the underlying granite, which is prominent in the lower walls of the canyon nearly to Hackberry. The relations of the lava to the granite are well exposed between Crozier and Valentine, as shown in figure 33. The lava sheet constitutes an extensive elevated shelf or plateau north and south of Crozier and Valentine. It lies on an exceedingly irregular surface of the granite, filling up valleys and burying low peaks and ridges, as shown in figure 33. It was poured out in relatively recent geologic time, but before the valley of Truxton Wash was cut to the depth which it now has near Crozier and below.

Valentine.

Elevation 3,788 feet.
Kansas City 1,405 miles.

At Valentine is a school for the Hualpai Indians on a reservation of 730,000 acres. They are a branch of the Yuman tribe and are closely allied to the Supai or Havasu Indians living in Cataract Canyon. There are about 500 of these Hualpai Indians, the remnant of a large tribe which once controlled a wide area in the middle Colorado Valley. They were famous for their prowess in hunting and their general enterprise, but are making little progress toward civilization.

The granite in the gorge from Valentine to Hackberry is characteristic of much of the granite in the ranges of western Arizona. It is very massive and coarse-grained and weathers out in typical rounded forms or huge bowlders. This process is facilitated by numerous joints,[1] which cause the rock to break into large blocks; these blocks on weathering soon lose their corners, so that the resulting pinnacles and masses have rounded forms.

Hackberry.

Elevation 3,554 feet.
Population 84.*
Kansas City 1,410 miles.

Hackberry is sustained mainly by a few small mines and ranches in the adjoining region. Here the train passes northwestward out of the granite gorge into the wide desert slope or plain known as Hualpai Valley. (See Pl. XXXVII, *A*, p. 140.) The Peacock Mountains, a granite ridge of considerable prominence, project out of it on the west; on its east side are granite slopes surmounted by the lava-capped plateau. The westward-facing edge of this plateau, extending far south from Hackberry, is known as the Cottonwood Cliffs.

Antares.

Elevation 3,608 feet.
Kansas City 1,416 miles.

At Antares the railway reaches the summit of the low northern extension of the Peacock Mountains, the granite of which crops out on both sides of the track. A few miles north and northeast are the precipitous slopes of the Grand Wash Cliffs, which extend far to the north, crossing Colorado River 75 miles north of this place, at the western outlet or termination of the Grand Canyon.

These cliffs form the last step in the descent across the great succession of sedimentary rocks constituting the high plateau of Arizona. They are capped by the lower part of the Redwall limestone, lying on

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[1] Joints in rocks are cracks, generally not of great length, due to shrinkage or earth movements. They may run in various directions or may be arranged in sets of nearly parallel cracks which intersect other sets at approximately constant angles. Joints differ from faults in being much smaller fractures that show little or no slipping of the rock along the break.

500 feet or more of sandstones and shale of the Tonto group, and have a long rugged lower slope of granite descending to the Hualpai Valley. The line of the escarpment is nearly straight. Part of its height is apparently due to a fault passing along its western foot, with uplift on the east side, as shown in figure 34. This fault probably has a displacement of 1,000 feet or more, as indicated by the extent to which the strata are elevated.

At the Grand Wash Cliffs the plateau country ends, for although some of the ridges of volcanic rock to the west have tabular surfaces the great plateaus of nearly level sandstones and limestones which occupy a large portion of Arizona and New Mexico cease at these cliffs. In northwestern Arizona, southern Nevada, and California north of the Santa Fe Railway the desert basins are separated by ridges that trend northward. The Peacock Mountains, south of Antares, are the first of these ridges, and many others will be seen in the journey west to Colorado River and in southeastern California.

Doubtless the sedimentary rocks of the high plateau extended across most or all of this area in former times, but they have been broken into blocks by numerous faults and mostly removed, leaving the underlying granite bare. In places, however, the granite was covered later by great masses of volcanic material which are the most prominent features of the area.

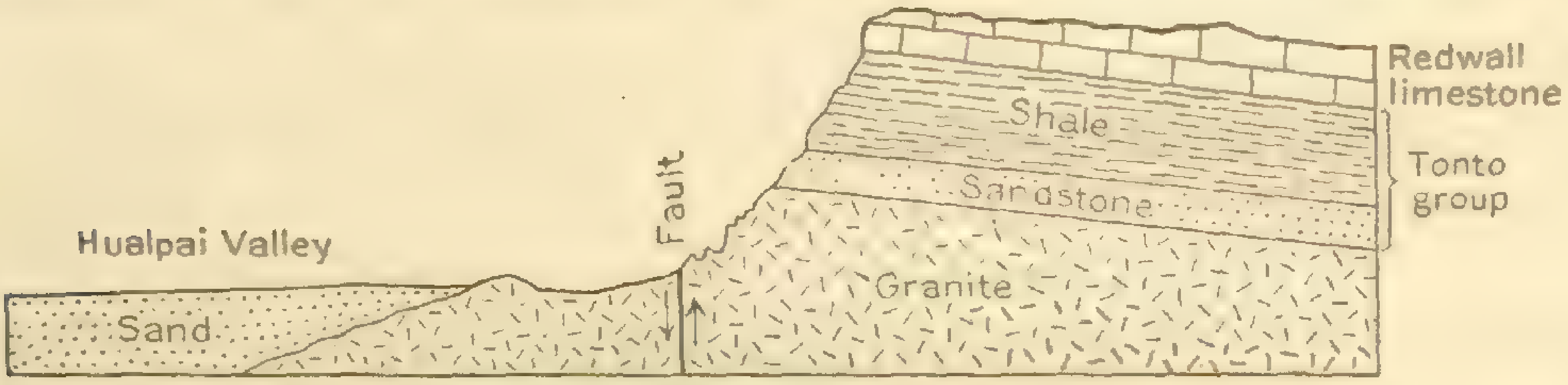
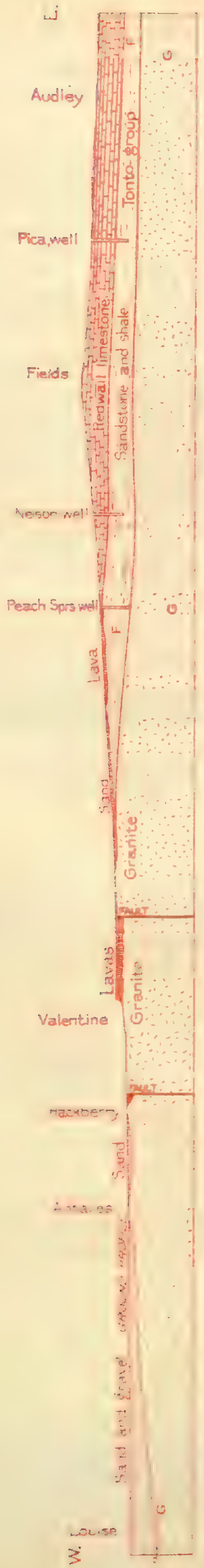


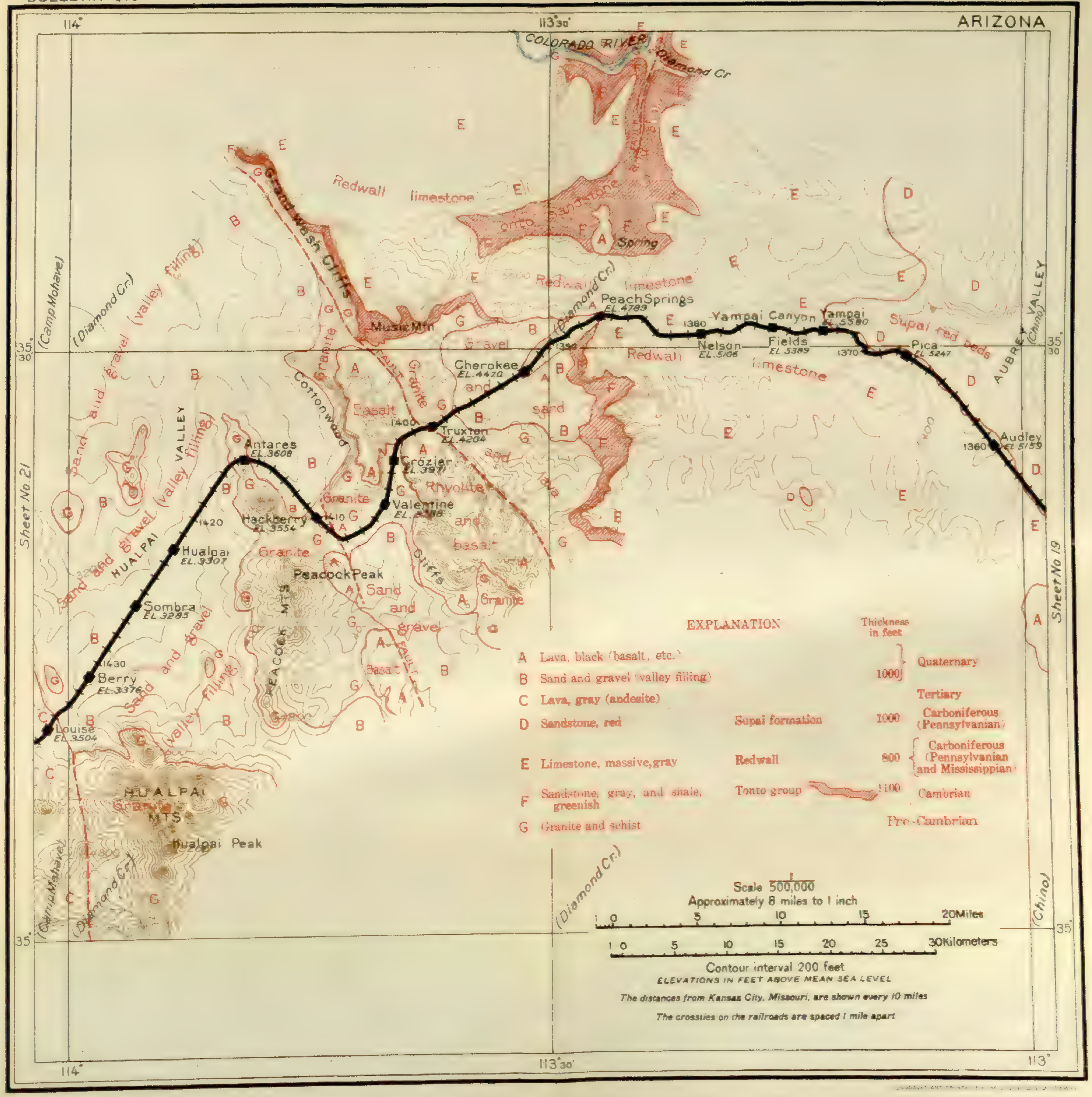
FIGURE 34.—Section of the Grand Wash Cliffs, north of Hackberry, Ariz., looking north.

From Antares to Kingman the railway ascends Hualpai (wahl′pie) Valley, a typical flat-bottomed desert valley, which extends north to Colorado River. It presents wide areas of smooth land with excellent soil and mild climate, which would yield large returns to agriculture if water were available for its reclamation. There is, however, but very little water underground, and although at the lower part of the valley is Colorado River, which carries a vast quantity of water, this stream lies more than 2,000 feet lower than the district visible from the railway. Pumping water to that height for irrigation is now regarded as impracticable.

At the south end of the Hualpai Valley, south of Berry siding and east of Louise siding, rise the Hualpai Mountains, a high ridge consisting mainly of granite, similar to the Peacock Mountains. On the west side of Hualpai Valley, as seen from points between Hackberry and Louise siding, there is a high ridge known as Black Mesa,



SECTION SHOWING RELATIONS OF ROCKS ALONG SANTA FE RAILWAY BETWEEN AUDLEY AND LOUISE, ARIZ.
VERTICAL SCALE IS 5 TIMES HORIZONTAL



consisting of a succession of sheets of rocks of volcanic origin of a character not found in the region farther east but occupying large areas in the country to the west.[1]

Kingman.

Elevation 3,336 feet.
Population 900.*
Kansas City 1,437 miles.

Kingman (see sheet 21, p. 148) is sustained mainly by extensive mining operations in the adjoining mountains. The mines have been opened for many years, and some of them have produced a large amount of ore. The principal mines are in the Cerbat Mountains, 8 or 10 miles north of Kingman, and are reached by a railway which branches from the main line at McConnico. Some of the ore is brought to Kingman for reduction.

West of Kingman there are railway cuts in the volcanic series which extends south from Black Mesa. These cuts show that there are several flows of rhyolite separated by thick beds of fragmental materials. The lavas issued from vents and flowed more or less widely on all sides, the earliest one apparently filling the inequalities of an irregular surface of granite. The tuff consists of coarse volcanic ash blown out of the craters or cracks of eruption at intervals between the lava flows. Some features of the succession in the canyon between Kingman and McConnico are shown in figure 35. The beds lie nearly horizontal, and the railway descends across their edges on the down grade through the canyon. The granite floor is reached

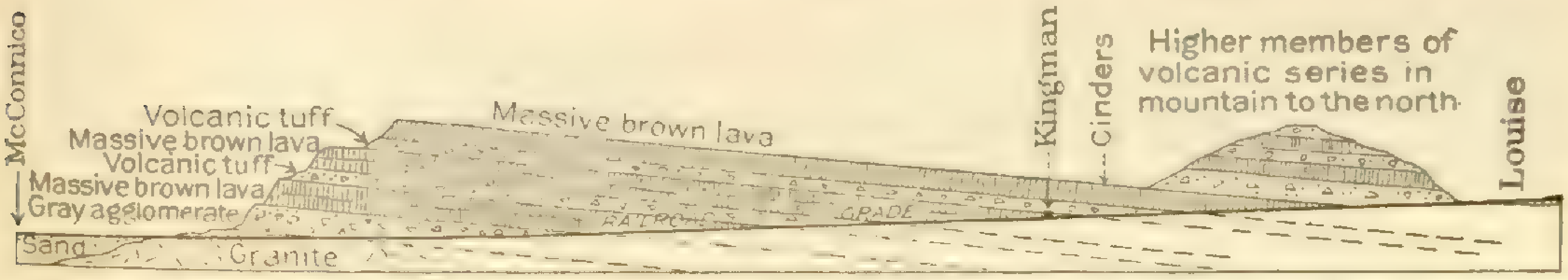


FIGURE 35.—Section showing relation of volcanic rocks between Louise and McConnico, Ariz., looking northwest.

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[1] The succession consists of an alternation of lava flows of various kinds, mostly rhyolite, with thick beds of light-colored tuff and volcanic ash, in part capped by flows of black lava (basalt). These rocks are in thick sheets, which in Black Mesa dip at a low angle to the east. They are much older than the late lava flows (basalts) of the Ash Fork country and the San Francisco Mountains, but may be of the same or nearly the same age as the older lavas of the San Francisco Mountains, Bill Williams Mountain, Picacho Peak, and Mount Floyd.

Undoubtedly these lavas were once very much more extensive than at present, for they have been uplifted, tilted, and in large part removed by erosion. They were poured out over the surface in flows, in most places to a thickness of 100 feet or more. The tuff is fine-grained material, differing from the basalt cinder in being less coarsely cellular. It is mostly of light color and consists mainly of ash and fine-grained pumice blown out of craters and deposited in great sheets over the lava flows or other surfaces. In most places it has in turn been covered by later lava flows, the eruptions consisting of alternations of lava outflows and material ejected in fragmental condition. There were also mud flows consisting of materials similar to the tuff and ashes but poured out, mixed with water, and spread over the surface in plastic condition, in places to a thickness of 50 feet or more.

finally, and in the next few miles this rock is seen to extend along the base of the mountain to the north and south, underlying the younger volcanic series.

A short distance beyond McConnico is a projecting spur of the granite which shows in low cuts on both sides of the track. From Hancock, the next station, the railway goes a little west of due south across Sacramento Valley, a characteristic southwestern desert consisting of a long, wide, flat-bottomed valley bordered by mountain chains of very irregular outline and sustaining a very scant vegetation. The sandy floors of such valleys slope up gradually to the foot of the mountains, where they give place abruptly to steep rocky slopes, as shown in Plate XXXVII, *B*. The valleys are underlain by deposits of sand, gravel, and other wash from the mountains, and in some areas well borings show that deposits of this sort attain a thickness of more than 1,000 feet. The detrital materials partly fill valleys that were excavated at a time when the region was higher than it is at present.

At Drake siding (milepost 527) there are excellent views to the west over a typical desert valley to the foot of Black Mesa, 8 miles away. This mesa, which rises about 1,500 feet above the valley, consists of a great succession of alternating lavas and tuffs similar to those at Kingman, in beds tilted slightly to the west.

At milepost 537 there is a 10-foot cut in the valley filling, showing the succession of gravel and sands.

Erosion proceeds with considerable rapidity in the desert region, notwithstanding the scarcity of continuously running water, for rock disintegration is accelerated by the great daily variations in temperature. The rocks are heated to 125° or even higher on the hot summer days and cool off rapidly at night to 70° or less, a difference of 50° or more; and in spring or autumn, when the sun heat is less, the night temperatures are relatively lower. In winter there is frost in the higher lands, but this factor is less effective.

The weather in the deserts of the Southwest is peculiar, and so far as plant growth is concerned there are three seasons—the warm, moderately moist spring, from March to May, where growth is rapid; the long drought of June to November, when plants rest except during showers; and the winter, from December to February, when it is too cool for vegetation to advance materially.

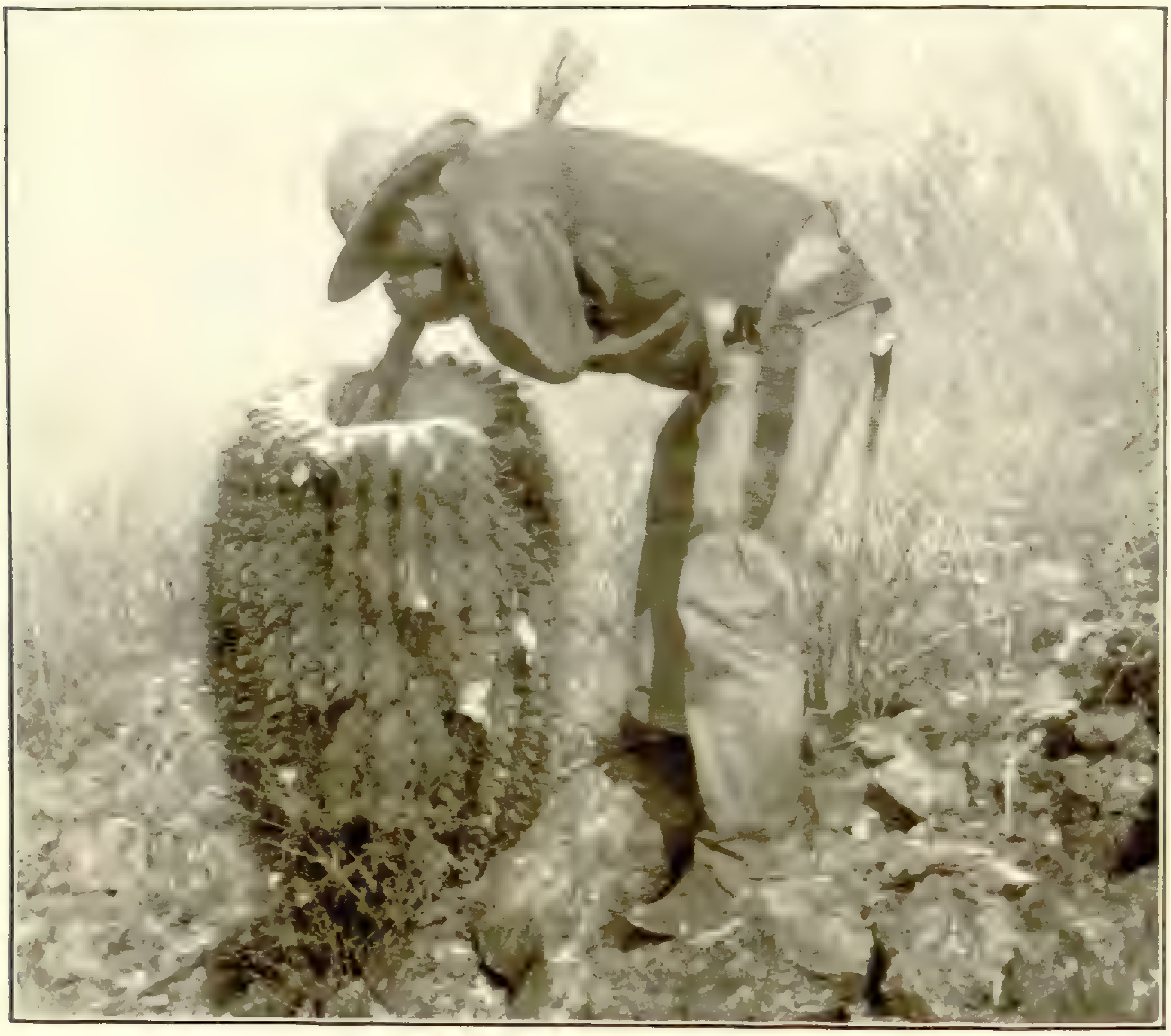
The desert plants present considerable variety and have special characteristics that adapt them to their environment. The most conspicuous plant, covering the desert flats from Kingman, Ariz., to Hesperia, Cal., is the creosote bush (*Covillea tridentata*). This plant grows 2 to 6 feet high and is rather widely spaced, after the habit of desert plants, which require wide-spreading roots in order to

A. TYPICAL DESERT VALLEY OF NORTHWESTERN ARIZONA.

View northward from north end of Hualpai Mountains near track of Santa Fe Railway. Granite Mountains to right; Grand Wash Cliffs in the distance.

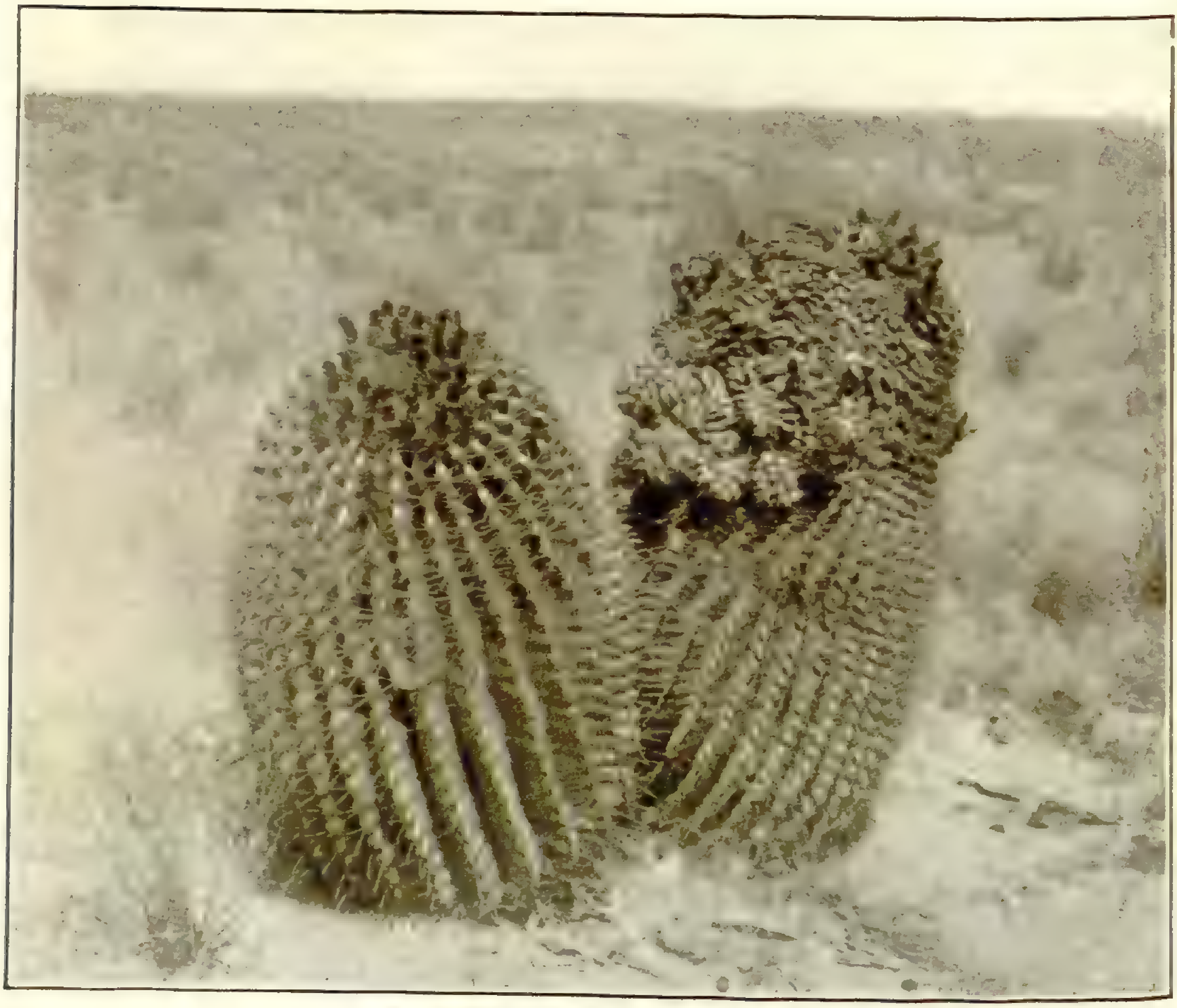
B. EDGE OF DESERT PLAIN ON WEST SIDE OF HUALPAI MOUNTAINS, ARIZ.

The sandy plain gives place abruptly to a slope of granite which is weathered into huge fragments.



A. A WATER BOTTLE IN THE DESERT.

Taking a drink pressed from the pulp that forms the interior of a barrel cactus, or visnaga.



B. BARREL CACTUS, OR VISNAGA.

One of the larger cactuses of the deserts of western Arizona and southeastern California.

gather the moisture from an ample area. For most of the year its leaves are covered with a resin that acts as a protection against evaporation and also renders them very unpalatable to animals. The popular name is due to the tarry odor given off when the plant is burned. On the rocky slopes and less abundantly on the plains several species of cactuses will be noted, including the barrel cactus or visnaga (*Echinocactus wislizeni lecontei*; Pl. XXXVIII), the smaller *Echinocactus johnsoni*, and clusters of the niggerhead cactus (*Echinocactus polycephalus*), which bears beautiful deep-red flowers in the early summer. All these cactuses are covered with large spines and contain considerable water, which is protected from evaporation by the thick skins of the trunk. The desert rats gnaw into some of them and clean out their watery pulp, leaving an empty shell of thorns. Travelers often obtain a drink of fair water from the barrel cactus. On some of the desert slopes grow the curious candlewood bushes, or ocotillo (*Fouquieria splendens;* Pl. XXXV, *B*, p. 134), the tips of which are brilliant with flame-colored blossoms in the spring. The paloverde (*Parkinsonia torreyana*), a bush or small tree consisting entirely of green spikes, grows in many of the valleys, associated with the uña del gato (oon′ya del gah′to), or cat claw (*Acacia greggii*), a bush with myriads of little curved thorns and deliciously fragrant yellow blossoms. On some of the sandy soils are many yuccas or soap weeds of several species, which in the spring send up slender stalks bearing clusters of cream-white flowers.

The desert animals are small and are not often in sight. The rats, which live in large colonies in the sandy areas, are nocturnal, and most of their companions have the same habit. Various lizards and the bold little horned toad (*Phrynosoma platyrhinos*) are abundant, and in places the variety of rattlesnake known as "sidewinder" (*Crotalus cerastes*) is found. This common name refers to his sidelong motion both in locomotion and attack. The rare tiger rattler (*Crotalus tigris*) lives in the rocks in many out-of-the-way places. The Gila monster (*Heloderma suspectum*) does not often come as far north as the Santa Fe line, but a few are reported from the Colorado bottoms near Needles and even along Virgin River in southern Utah. The larger lizard known as the chuckwalla (*Sauromalus ater*) may be seen here and there, and the Indians find him as palatable as chicken. The tortoise (*Gopherus agassizii*) roams widely over the desert, and his empty shell is a common sight. Most of these tortoises are from 8 to 10 inches long; some are larger. They are generally found far from water holes, and it is a marvel that they can exist with so little water.

Yucca.

Elevation 1,804 feet.
Population 138.*
Kansas City 1,461 miles.

The railway company sank a well 1,004 feet deep at Yucca some years ago which yields a supply of excellent water rising within 104 feet of the surface.[1] The east face of Black Mesa continues in view beyond Yucca. The general succession of beds in this face is shown in figure 36. The rocks present considerable variety, comprising light-colored lavas (rhyolites) and black lava (basalt) in widespread sheets of varying thickness, separated by thick deposits of light-colored tuffs, which were thrown out of volcanic vents in fragmentary condition. Extensive cuts in this volcanic series through a southern projection of the mesa show massive breccia and tuff capped by a sheet of light-colored lava (rhyolite). The breccia consists of large fragments of volcanic rocks of various kinds, and some of the material appears to have flowed out mixed with hot water. Beyond this point the railway swings to the west around the south end of Black Mesa, but it continues to follow Sacramento Wash to Colorado River at Topock.

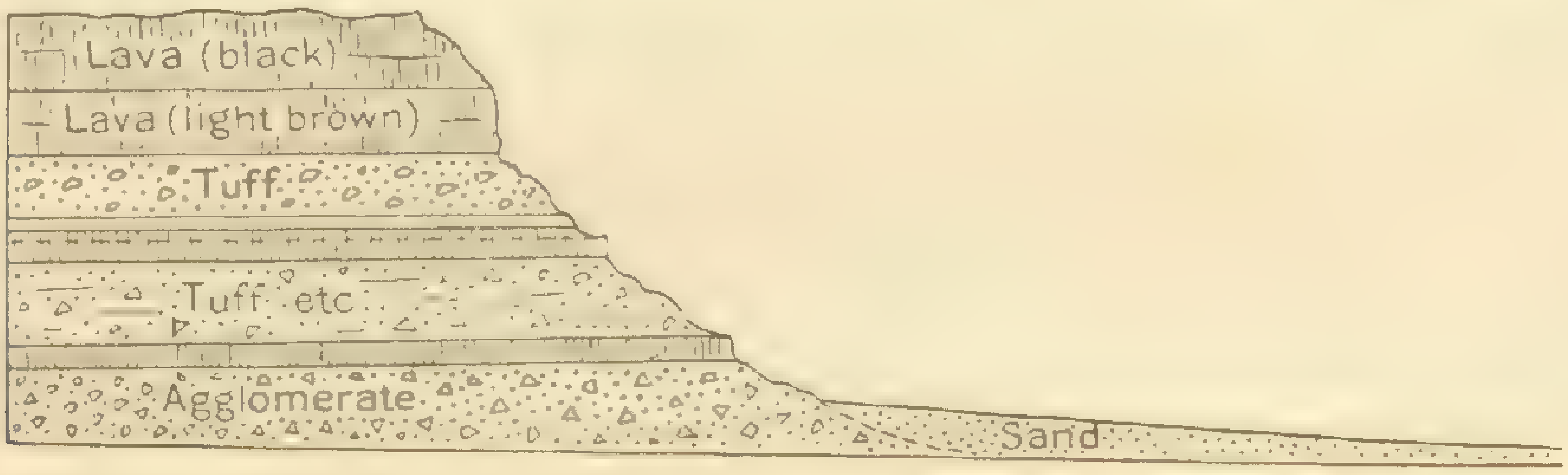


FIGURE 36.—Section showing succession of volcanic rocks in east face of Black Mesa, northwest of Yucca, Ariz.

Haviland.

Elevation 1,465 feet.
Kansas City 1,467 miles.

A short distance west of Haviland siding are low terraces and hills composed of the valley filling, and at milepost 547 is a railway cut through one of these, exposing from 30 to 50 feet of bowlders and sand.

Powell.

Elevation 764 feet.
Kansas City 1,480 miles.

At Powell Colorado River is in sight to the northwest, occupying a broad valley between typical desert ranges. About 2 miles beyond Powell there may be seen in the foothills of the rugged mountains to the south a hole through a peak, which is known as the "Eye of the Needle." It has been eroded in a narrow ridge, largely by wind-blown sand, which is an effective agent of rock sculpture in the arid regions.

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[1] The water comes from a mass of tuff lying at depths of 555 to 805 feet. This tuff is underlain by 22 feet of dark lava, 78 feet of tuff, and 99 feet of "granite."

At Topock (Mohave for bridge) the bank of the Colorado is reached at a point where the water is only about 480 feet above sea level. This river marks the boundary between Arizona and California, and a large bridge crosses it to the California side. To the north the river flows in a wide valley. To the south it passes into a rocky canyon through a chain of jagged ridges which extends from northwest to southeast. A group of pinnacles on one of these ranges about 3 miles southeast of Topock, and plainly visible from that place, is known as The Needles. The rocks of these mountains are largely of the younger volcanic series, similar to those constituting Black Mesa, a few miles to the northeast. They form sharp peaks of striking outline owing to rapid erosion along joint planes traversing the hard massive igneous rocks.

Topock, Ariz.
Elevation 505 feet.
Kansas City 1,487 miles.

Colorado River was reached by two of the early Spanish explorers from Mexico in 1540; one was Melchior Díaz, who came across country and went only a short distance above Yuma, and the other was Alarcón, who came in boats from western Mexico. Owing to the custom of the natives of carrying firebrands in winter with which to warm themselves, Díaz named the stream Río del Tizón (Firebrand River), a name more distinctive than the present one, which often causes considerable confusion because no part of the river is in the State that has the same name.

California, known as the Golden State, is next to the largest State in the Union. It is 780 miles in length and about 250 miles in average width, though owing to its shape it covers very nearly as wide a range in longitude as Texas. It has also great diversity in altitude, for some of its desert valleys are below sea level and in the Sierra Nevada are the highest peaks south of Alaska. The State has a total area of 156,092 square miles, being nearly equal in size to New England, New York, and Pennsylvania combined. The population of California in 1910 was 2,377,549, or about one-tenth that of the Eastern States named. This was a gain of 60 per cent in 10 years. The number of persons to the square mile is only slightly more than 15, having doubled since 1890, but the density varies greatly, becoming very low in the desert regions east of the Sierra Nevada. The ratio of males to females is 125 to 100. The area covered by public-land surveys is 123,910 square miles, or nearly 80 per cent of the State, and 21 per cent of the State was unappropriated and unreserved July 1, 1914.

California.

Along the State's 1,000 miles of bold coast line there are comparatively few indentations. The bays of San Diego and San Francisco are excellent harbors, but they are exceptional.

The climate of California varies greatly from place to place. Along the coast in northern California it is moist and equable. Around San Francisco Bay a moderate rainfall is confined almost wholly to the winter, and the range in temperature is comparatively small. In parts of southern California typical desert conditions prevail. The great interior valley is characterized by moderate to scant winter rainfall and hot, dry summers. Snow rarely falls except in the high mountains.

Forests cover 22 per cent of the State's area and have been estimated to contain 200,000,000,000 feet of timber. They are notable for the large size of their trees, especially for the huge dimensions attained by two species of redwood—*Sequoia washingtoniana* (or *gigantea*), the well-known "big tree" of the Sierra Nevada, and *Sequoia sempervirens*, the "big tree" of the Coast Ranges. Some of these giant trees fortunately have been preserved by the Government or through private generosity against the inroads of the lumberman.

The 21 national forests in California have a total net area of 40,600 square miles, or about one-fourth of the State's area. The national parks in the State are Yosemite (1,124 square miles), Sequoia (252 square miles), and General Grant (4 square miles).

Agriculture is a large industry in California, and with the introduction of more intensive cultivation its importance is increasing rapidly. In 1914 the grain crops yielded nearly 63,000,000 bushels, of which two-thirds was barley. The value of the cultivated hay crop that year was over $43,000,000. In the variety and value of its fruit crops California has no rival in the United States, if indeed in the world. Its products range from dates, pineapples, and other semitropical fruits in the south to pears, peaches, and plums in the north, but it is to oranges and other citrus fruits and to wine grapes that California owes its horticultural supremacy. During the season from November 1, 1913, to October 31, 1914, California produced 48,548 carloads of citrus fruit, 42,473,000 gallons of wine, and 12,450 tons of walnuts and almonds. The value of the annual crop of citrus fruits is about $50,000,000, and of olives $2,200,000. Wine and brandy yield to the grape industry $25,500,000 annually. Some other notable products are hops, about 20,000,000 pounds; lima beans, 1,150,000 sacks; beet sugar, 162,000 tons; potatoes, 11,000,000 bushels; and butter, 54,000,000 pounds.

Of its mineral products, petroleum ranks first in total value and gold next. In 1914 California's output of petroleum was valued at $48,466,096, about 25 per cent of the world's yield, and its output of gold at about $21,000,000. In the production of both petroleum and gold California leads all other States in the Union. Other mineral products are cement $10,500,000, copper $5,000,000, silver $750,000, mercury $750,000, and borax $1,500,000.

California's fisheries bring a profit estimated at $3,000,000 a year, the canning of the delicious tuna yielding about $2,000,000. Nearly 11,500,000 pounds of wool was clipped in 1914, estimated to be worth $1,852,000. In most parts of the State only a small part of the water available for power or irrigation has been utilized, and large areas of swamp lands are being reclaimed. Cotton and dates promise to be important crops in the southeast corner of the State, and rice production is increasing rapidly.

Sir Francis Drake, who landed on the California coast in 1579, named the place New Albion, but later the name California was applied, taken from a Spanish romance. From 1769 to 1823 many missions were established under the direction of the Franciscan friar Junípero Serra and other missionaries of his order, and most of them still remain, although some are in ruins. The first overland caravans to California began in 1827. The discovery of gold by J. W. Marshall at Sutters Mill in 1848 brought a large crowd of gold seekers and settlers.

California was formerly a part of Mexico but in 1848 was ceded to the United States and on September 9, 1850, was admitted to the Union as a State.

At the California end of the bridge at Topock there is a conspicuous outcrop of red conglomerate in massive ledges which is part of the older valley filling. It outcrops at other places farther west, and a small mass of the same rock also appears on the east bank of the river just north of the bridge. From the bridge to Needles the railway follows the west bank of the river, and owing to the many small gullies and terraces there are numerous cuts for the railway grade. These cuts exhibit materials of the valley filling, which appear to comprise a younger, high-level gravel and sand, lying on the somewhat irregular surface of an older deposit of silt of pale-buff or greenish tint, in large part distinctly bedded. This older material lies 80 to 100 feet above the present river and was laid down at a period of slack current, during a time when there were no notable freshets for many years.

Needles, Cal.
Elevation 483 feet.
Population 3,067.*
Kansas City 1,499 miles.

Needles is built on a low terrace or higher flood plain of Colorado River, less than a mile from the river bank. It is a railway division point with a large hotel at the station, where most trains stop for meals. This hotel is named El Garces after Francisco Garcés, a Spanish missionary who journeyed through this country in 1771–1774 and visited the Hopis in 1776. Needles is becoming a winter resort owing to its mild, equable climate and large proportion of sunny days. Many trees have been cultivated here, including date palms and the tall, stately palm *Neowashingtonia filifera*, a native of the Colorado Desert, which is extensively utilized for ornamental plantings in Los Angeles and other towns in the coastal region of southern California.

Many Mohave Indians live along the flats at Needles, and they have a reservation of considerable size extending along the river bank some distance above the city, where they dwell in small, low buildings roofed with brush and sand. They cultivate small areas of the fertile bottom lands along the river and raise grain and vegetables for their own use and for the local market. Some of them come to the trains, offering bead trinkets of various kinds for sale to the passengers. They are a branch of the Yuman stock, numbering about 1,400 and in general diminishing in number. The name Mohave mo-hah′vay is Yuman for the three pinnacles of the Needles south of Topock. Formerly these Indians were warlike, but this would not be inferred from their present appearance.

In the western part of Needles there is a steep ascent to a long, moderately steep slope which rises to the foot of the Sacramento Mountains[1] on the west. This slope is the surface of a thick body of sand, gravel, and bowlders derived from the mountains. It is intersected by many gullies or small valleys which carry large volumes of water on the rare occasions when there is rain.

Leaving Needles the train begins to climb the slope, running northwestward toward a pass that separates the Sacramento Mountains on the south from the Dead Mountains on the north. On this slope there are many railway cuts that reveal the materials of which it is composed. Some of the deposits are fine silts; others are cross-bedded sands containing a large amount of coarse material. All are of recent geologic age.

Two miles beyond Java the rocks of the mountains are exposed in railway cuts and slopes of Sacramento Wash, the valley of a stream which has cut the pass through the mountains. The material is gneiss or mica schist, probably pre-Cambrian, which constitutes the greater part of the ranges north and south.

Near Klinefelter siding this rock gives place to coarse, massive red conglomerate, which at several points rises in mounds of moderate height. This rock is not old, but appears to be a valley filling that accumulated before the deposition of the gravel and sand which form most of the slopes of the desert valley. The materials were derived largely from the adjoining mountains of gneiss, but they include also some volcanic tuff and agglomerate and old lava (basalt). The beds are tilted at various angles, the dip being to the southwest in a considerable area west of Klinefelter and almost due west, at angles approaching the vertical, along the foot of the Dead Mountains, northeast of that place. A short distance beyond Klinefelter siding a number of springs issue from this deposit, affording water which has been extensively utilized by the railway company for its locomotives. These springs are just west of the track.

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[1] The Sacramento Mountains consist of schists of supposed Archean age. The highest part of the mountains, 10 miles southwest of Needles, is capped by a thick body of latite. From the occurrence of fragments of blue limestone in the slope southwest of Needles it is probable that some Paleozoic rocks also occur in the range. Near the foot of the range southwest of Needles masses of red conglomerate in which are included sheets of basalt appear in small knobs and probably this material underlies the alluvium of the slopes.

A few rods east of the railway, at milepost 590, a mile north of Klinefelter, the conglomerate stands nearly vertical and includes between its beds a 6-foot sheet of basalt. At a place just east of the tracks it includes another sheet of basalt.

At Klinefelter the railway is in a wide desert valley that is drained through Sacramento Wash, which heads far to the west. To the east rise the Dead Mountains,[1] culminating in Mount Manchester; to the southwest is Ibis Mountain, which ends southwest of Ibis siding. The up grade continues past Ibis to the summit, half a mile east of Goffs. The divide at this place (altitude, 2,584 feet) is in the wide sand plain of the desert, but there are ridges of granite not far to the north and south, and doubtless here this rock is at no great distance beneath the surface. At Goffs, however, in a well 926 feet deep, from which the railway company obtains water, the first rock reported was at a depth of 680 feet.

A branch railway leading to Barnwell and Searchlight, two mining camps to the north, begins at Goffs, which is an old settlement, supported mainly by gold, silver, and copper mines in the mountains to the northeast, northwest, and south.[2] The ores occur in part as veins, in part as irregular bodies of shattered altered rocks, somewhat after the manner of the ore bodies at Goldfield and Tonopah, Nev.

Goffs.
Elevation 2,584 feet.
Kansas City 1,530 miles.

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[1] The Dead Mountains, northeast of Ibis, consist of schists, in most of which the foliation is well defined, dipping in part at a low angle to the west. The slopes and ridges south and southwest of Klinefelter show a variety of rocks. For the first few miles there is much breccia and conglomerate that include sheets and masses of basalt. The ridges farther southeast are granite and schists. These pass down to the west under latite or rhyolite and breccia, which appears first in knobs and finally rise in prominent peaks near Eagle Pass, 10 miles south of Klinefelter. For about 2 miles the granite and rhyolite are separated by limestone and sandstone, which are of Paleozoic age and contain at one point fossils that are probably Carboniferous. Six miles southwest of Klinefelter is the high, conspicuous Tabletop Mountain, consisting of a cap of basalt on a mass of tuff and agglomerate lying west of the main body of rhyolite. The high ridge next northwest, which extends nearly to Ibis, is composed of schist and light-colored granite. The Ibis mine (now idle) is on its east slope.

[2] A short distance south and southeast of Goffs is the north end of a mountain range which extends far southward. It consists largely of granite, partly schistose,

From Goffs the railway runs nearly due southwest for many miles (see sheet 22, p. 158), descending continuously into one of the great interior basins that are characteristic of a large part of southeastern California. The slope is covered with a thick mantle of gravel and sand, constituting a typical desert plain from which detached mountain ranges rise abruptly at intervals. These ranges have steep sides, are deeply recessed by canyons, and have remarkably ragged or pinnacled summits. The plain slopes up toward the mountains and is built of the products of their disintegration. The deposits are thick, for they have been accumulating for a long time and every rain causes a local flood that carries the rock waste farther and farther down the slopes and at the same time adds a new supply from the mountain sides.

There are many instructive illustrations of the relations of these desert plains from Needles all the way across southern California, but some of the most impressive ones are in the region southwest of Goffs. Rain is infrequent in this region, as the average total precipitation is considerably less than 6 inches a year. However, much of the rain falls in remarkably heavy showers, or cloudbursts, which quickly flood the drainageways with a swiftly flowing body of water sufficiently powerful to roll large bowlders and to transport a vast amount of fine material far down the slope. These floods are exceedingly

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cut by masses of darker rocks. It also contains some large bodies of diorites which are cut by the granites. Half a mile southeast of Goffs, at the foot of the main mountain mass, there is a conspicuous butte, capped by black lava (basalt). Two miles south of the station there is a high peak, known as Black Top, just west of the main mountain slope. Its tabular top is due to a thick sheet of lava (basalt), which lies on a thick deposit of sand and granite bowlders that are underlain by the coarse granite of the main mountain slope. This peak is a conspicuous feature for many miles to the west.

Three miles north of Goffs several low hills rise above the desert. They consist of white granite, a material that also constitutes the higher ridges farther north to and beyond the Leiser-Ray mine, 8 miles northeast of Goffs, and the California copper mine, 9 miles northwest of Goffs. A prominent butte known as Signal Peak, a short distance southeast of the Leiser-Ray mine, is capped by black lava (basalt) similar in relations to the lava caps south of Goffs and of the same age. Smaller masses of this rock also rise from the desert in low buttes 8 miles northwest of Goffs. They are parts of lava flows that were poured out over the desert surface at a time not very remote.

In the high ridges in the region north and west of Vontrigger (see sheet 22) the next station on the Barnwell branch, 10 miles northwest of Goffs, there is a thick series of Tertiary igneous rock of the same character as that in Black Mesa, near Kingman, Ariz. It overlies granite along a line that passes a short distance west of the California mine. The series consists of thick sheets of tuff and agglomerate alternating with extensive flows of light-colored lavas (rhyolite and latite). These sheets dip to the east and southeast, and the harder beds present great steplike cliffs facing the west and northwest. These cliffs are conspicuous far to the north to the traveler from Goffs to Fenner, and northwest of Fenner abut against the east flank of the Providence Mountains.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
SANTA FE ROUTE
From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

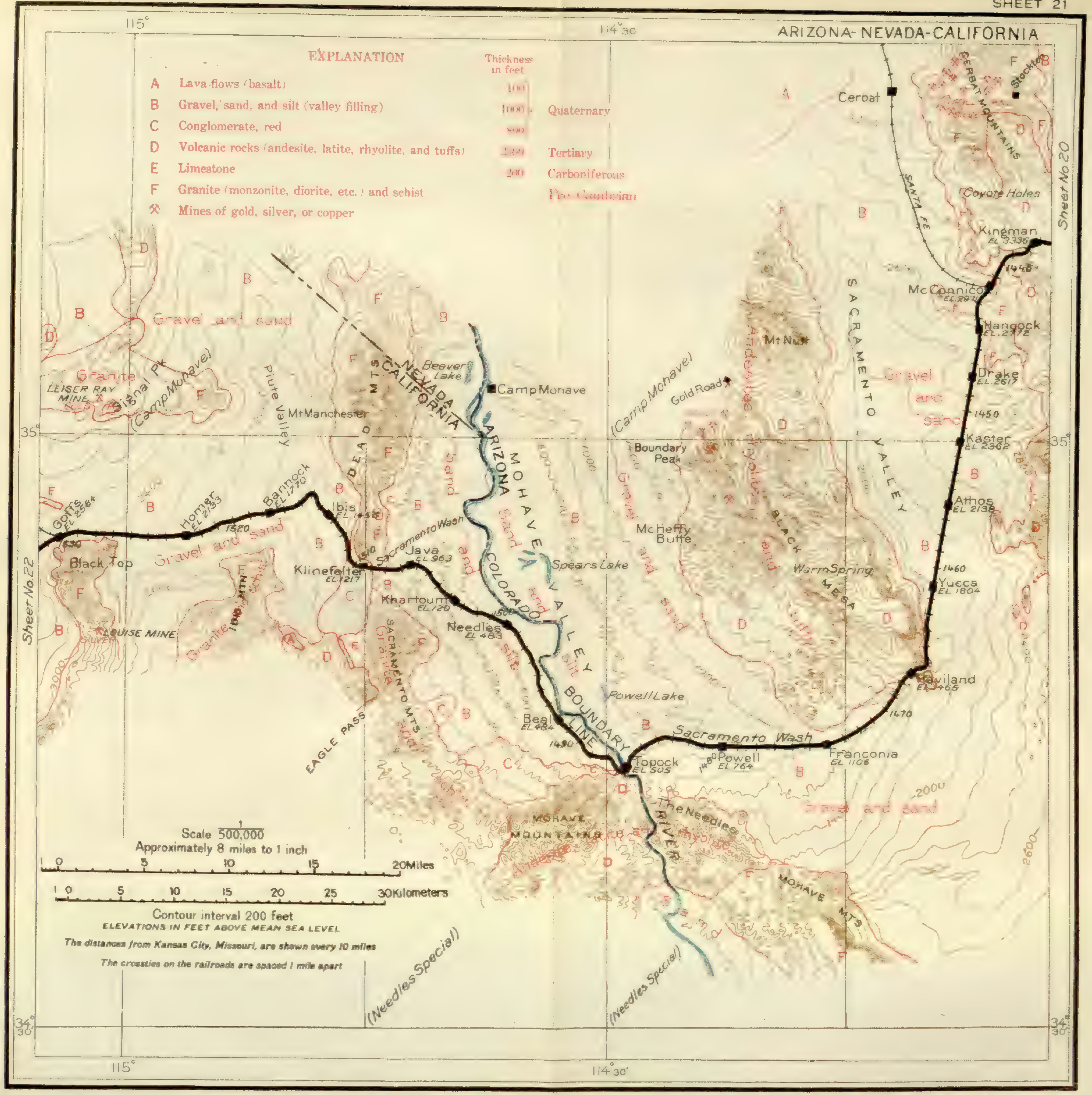
UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist   R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.



troublesome to the railway company, which must make long deflection ditches and dikes to prevent serious washouts. Work of this sort along the Santa Fe lines in the desert region has been as large an item of expense as flood protection and repair in regions where there are large rivers subject to freshets. The run-off is very rapid in the deserts, because the rocks are bare, the soil is hard, and most of the slopes are steep. Very little water passes underground, and springs, even in the mountains, are exceedingly rare. Much water, however, is lost by evaporation.

Fenner.
Elevation 2,096 feet.
Kansas City 1,540 miles.

Fenner is on a desert plain or flat-bottomed valley of considerable width. (See Pl. XXXIX, p. 150.) A few miles to the east rises the high mountain range which begins at Goffs and extends far to the south. Its higher part, southeast of Danby, is known as Old Woman Mountain. This range consists largely of granites but also includes some limestone which has been mostly altered to marble by the intrusion of igneous rocks. The heat and pressure of these intrusions are the agencies which have effected this change. The process is one of crystallization, the massive or earthy limestone changing into an aggregation of crystals, usually white, to form marble.

The prominent range known as the Providence Mountains, west and northwest of Fenner, consists of a thick mass of limestones and other sedimentary rocks (Cambrian, Devonian, and Carboniferous) lying on granites and cut by thick bodies of monzonite and rhyolite. These mountains are the south end of a great north-south divide which separates the Las Vegas and Colorado valleys on the east from the deserts on the west and which in general seems to be an important but little understood geologic boundary in this region. In its northern extension, known as the Charleston Range, near Good Springs, there are rich mines of lead and zinc, and a remarkable deposit of gold, platinum, and palladium ore has recently been discovered. The range contains also interesting stratified formations not found to the west in southern California. The southwestern course of the railway from Needles to Cadiz was determined for the purpose of paralleling the east side and getting around the south end of this range, which is reached at Cadiz.

The basin about Fenner is probably underlain by later volcanic rocks, portions of which protrude above the plain in many small buttes. One of these is a mile northeast of the station, and a group of them occurs about 10 miles due west of Fenner. They consist of rhyolite, a fine-grained brown glassy-looking rock, much of which contains cindery fragments and many vesicular cavities caused by the steam included at the time of outflow. In the midst of these rhyolite hills, 10 miles west of Fenner, there is an outcrop of pure white marble which some time may have economic importance.

From Fenner to Danby the railway descends the valley near its center. A short distance to the west rises a high ridge known as Clipper Mountain,[1] which consists mainly of a thick succession of Tertiary volcanic rocks, which lie on gneiss that crops out extensively at the north end of the range. This ridge is about 10 miles long and some of its peaks rise more than 1,500 feet above the surrounding plain. The rugged slopes of Clipper Mountain present a great variety of strong colors, mostly yellow and brown, due to the oxidation of the tuffs and other rocks.

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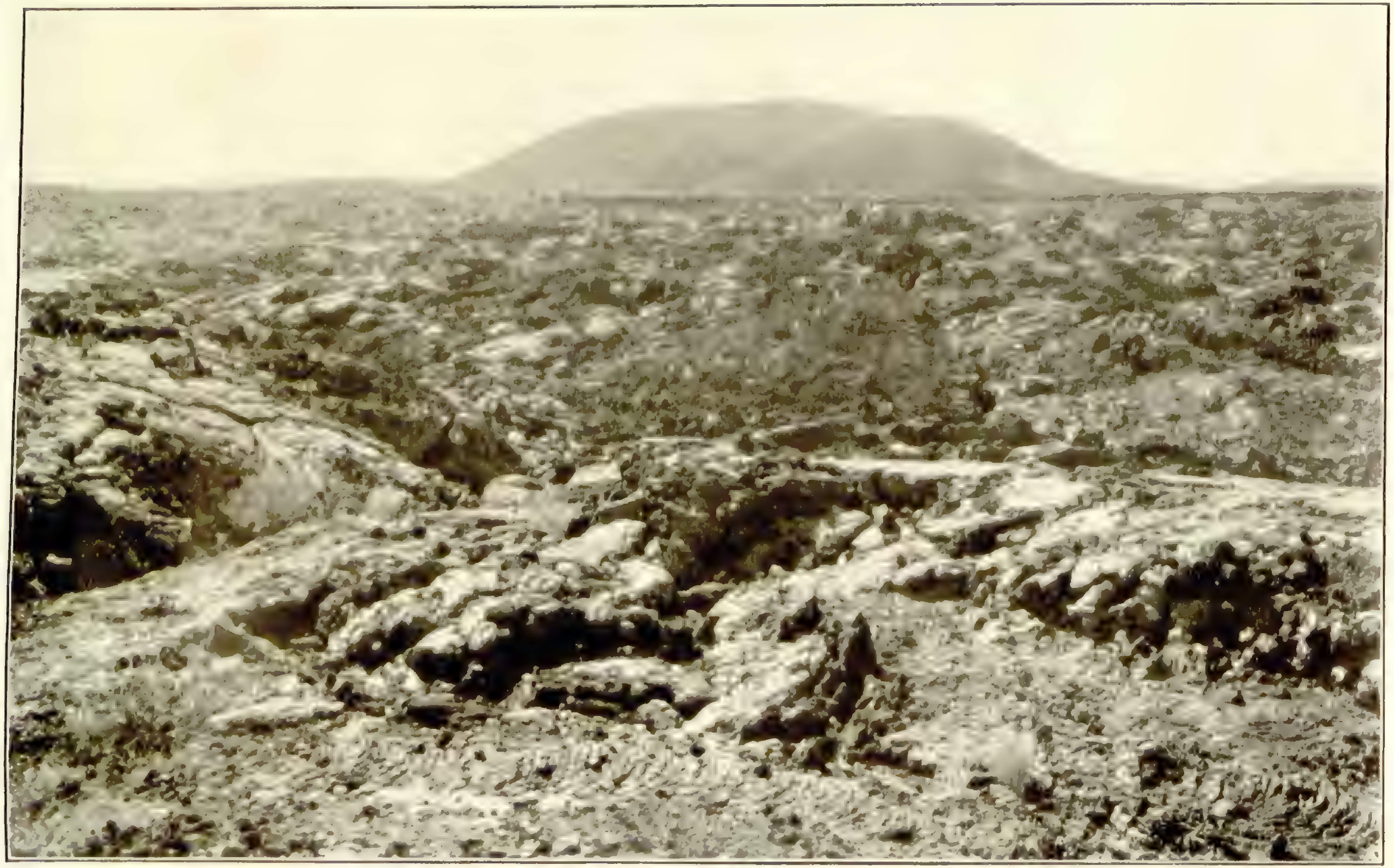
[1] The rocks of Clipper Mountain are principally tuffs and agglomerates, interbedded with many thick flows of light-colored lava (rhyolite) and penetrated by a number of thick stocks of this and other igneous rocks. The tuff and ash beds near the top are capped by a thick sheet of black lava (basalt), which dips northwestward. Small masses of this kind of lava also appear at several points in the plain south and southwest of the mountain, but these are probably of later age than the summit cap. The agglomerate, tuff, and ash of this succession were ejected from volcanic vents and probably accumulated very rapidly, with intervals in which eruptions of rhyolite and other lavas flowed over their surface. The final eruption was the sheet of black lava (basalt) now capping Clipper Mountain, which probably flowed out at the same time as the sheets capping Signal Peak, north of Goffs, and Black Top, southwest of Goffs. The same succession also constitutes the high ridge extending through Vontrigger to the east slope of the Providence Mountains northwest of Fenner.

Southeastern California presents the record of a varied succession of events, mostly of igneous activity on a land surface, during later geologic time. Great masses of molten rock were intruded through the various older sedimentary rocks, followed at intervals by the outflow of lavas and the ejection of fragmental volcanic material. Some of these volcanic outbursts were so recent that they appear to have been almost within the historic period. The largest bodies of lava, however, were accumulated in middle and later Tertiary time, when a vast amount of fragmental material was thrown out of numerous vents of various kinds and spread over a wide area. These formed thick deposits of breccias, which consist mostly of fragments of lava, tuff, or finer-grained ejected material of the nature of ash and cinders, in part mixed with large volumes of fine volcanic ash. Most of this ejected matter was piled up as it fell, but in some places water had a part in its distribution, and from some of the vents there also came extensive mud flows. At intervals and from place to place there were great outflows of lavas of various kinds, which spread widely over the surface of the deposits of fragmental material, and subsequently were buried beneath accumulations of breccia, tuff, and ash. In general, the order of rocks erupted in Tertiary time has been latite, rhyolite, diabase rhyolite, and several varieties of basalt. The configuration of the region was probably much smoother at that time than it is now, for in general the old rock surface on which the volcanic deposits lie appears to be smooth at most localities. In places, however, ridges of older rocks protruded which were not covered by the volcanic materials. After the main period of volcanic action in Tertiary time the region was uplifted and the beds broken and tilted. It is from the erosion of this irregular surface by streams and other agencies that most of the present land forms are derived. In places the uplifted volcanic rocks have been removed, laying bare the underlying older rocks. Several times after the uplift there were extensive eruptions of later lavas, some of them accompanied by the ejection of tuff, ash, and other fragmental material.

DESERT AT FENNER, CAL.

View southeastward to Piute Mountains. Knob of rhyolite in left middle distance.



MOUNT PISGAH, BETWEEN LUDLOW AND BARSTOW, CAL.

A recent cinder cone and its great lava sheet. View southward from a point near Santa Fe Railway. Note broken blisters and caverns in lava and the ropy surface of lava in the foreground.

By the judicious use of a small amount of water and fertilizer, date palms, cottonwoods, and various other plants have been cultivated at Danby, making the place an oasis in the desert. Water is obtained from a well, and an additional supply is brought by a pipe from a spring 4 miles to the northwest, where a tunnel has been run into the hillside in such a way as to gather the water seeping from a small fissure in the volcanic rocks. Clipper Mountain, with its bright-colored slopes and steep pinnacles of volcanic rocks, is a conspicuous feature north of Danby station. Five or six miles east of Danby are the Piute Mountains, and to the southeast rises Old Woman Mountain, both ranges presenting long, bare slopes and rugged peaks of granite.

Danby.
Elevation 1,353 feet.
Kansas City 1,554 miles.

From Danby to Siam, a distance of 7 miles, the railway descends the broad desert valley on a southwesterly course. Southeast of milepost 640 several scattered knobs[1] of volcanic rock rise from the desert a short distance east of the tracks. These are outliers of Ship Mountain, a short but prominent range which continues to a point 7 or 8 miles southeast of Siam. A deposit of volcanic ash and some associated tuff in the ridge 3 miles east of Siam is about 100 feet thick, and portions of it are snowy white and sufficiently pure to be serviceable as polishing powder. Material of this character is used in many of the cleansing powders now on the market.

Siam.
Elevation 1,037 feet.
Kansas City 1,563 miles.

A short distance south of Siam there is considerable limestone, most of which has been changed to marble by the heat of intruded granite. This marble constitutes a high ridge 2 miles southeast of Siam and several outlying knobs west of the foot of the ridge at intervals southward for 2½ miles. The marble is cut off to the north as well as to the south and southeast by the granite constituting the central portion of Ship Mountain. In the Siam mine, 2 miles southeast of Siam, which was worked for several years, considerable gold and copper ore was found along or near the contact of the marble and granite. In places in the altered limestone east of Siam there are seams and pockets of yellow and red ocher of excellent quality. This material is extensively used for paints.

North of the railway beyond Siam are the Iron Mountains, a narrow but prominent range which is in general a southward continuation of the Providence Mountains. To pass the south end of this range the railway has to be deflected far southward in its course beyond Goffs.

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[1] The knobs just east of milepost 640 consist of rhyolite, but farther back there is a small knob of basalt, and still farther southeast rises a prominent tabular mass in which a thick sheet of lava (basalt) caps a deposit of volcanic ash, overlying a thick body of angular fragments of gneiss. The sheet of basalt dips northeastward and passes beneath the desert plain, which is here about 10 miles wide and which extends to the west foot of Old Woman Mountain.

Cadiz.

Elevation 821 feet.
Kansas City 1,569 miles.

At milepost 646 the railway passes the south end of the Iron Mountains[1] and bears slightly north of west to Cadiz. Along the west side of the mountains is a westward-facing cliff of the sandstone and limestone, surmounting rugged slopes of granite. At a point on the mountain slope 2 miles northeast of Cadiz a quarry has been opened in dark Cambrian limestone, which yields a material of attractive appearance, but it has not yet been shipped to any great extent.

At Cadiz the main line is joined by a branch from Phoenix, Ariz., which crosses Colorado River at Parker, 60 miles below Needles, and rises with easy grade over the divide that separates the river valley from the long basin extending to Cadiz and beyond. One branch of this basin is followed by the main line of the railway from Goffs to Cadiz, far down its slope.

From Cadiz westward the course of the track is somewhat north of west, through the center of a series of wide basins bordered on both sides by high mountain ranges. The bottom of this basin is reached

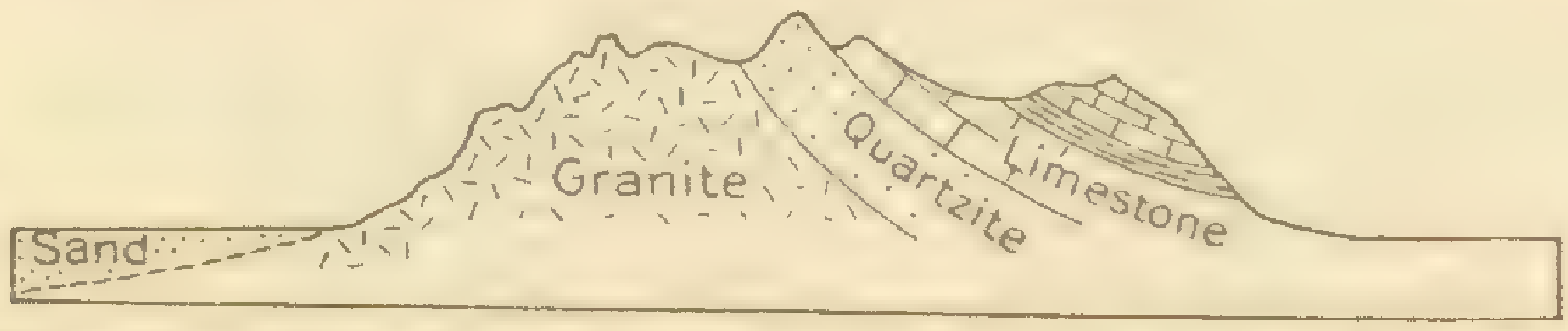

FIGURE 37.—Sketch section showing quartzite (hard sandstone) on granite at south end of the Iron Mountains, southwest of Siam, Cal., looking north.

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[1] The Iron Mountains present a considerable variety of rocks, including pre-Cambrian granite and overlying quartzites, limestones, and shales of Cambrian to Carboniferous age. These are cut by masses of intrusive rocks which have altered most of the limestone to marble. In places thick deposits of volcanic ash and tuff lie on the older rocks and are in turn overlain by a thick sheet of black lava (basalt), capped by a sheet of light-colored lava (rhyolite). The sheets of lava cap a succession of high eastward-sloping ridges on the summit and east side of the range, 6 to 8 miles north of the railway.

The granite crops out extensively in the two gaps near the south end of the range. It is overlain in ridges north and south of these gaps by rocks of Cambrian age, consisting of a basal quartzite with a thick body of overlying limestone and shale, all dipping steeply to the east. From the vicinity of milepost 645, which is about halfway between Siam and Cadiz, the contact of these sedimentary rocks on the granite is visible about half a mile northwest of the track, as shown in figure 37. The contact and the beds all dip at a moderate angle to the east. The granite has a wave-worn surface, and the beds were deposited on this surface when it was a sea bottom, a fact which establishes the age of the granite as pre-Cambrian. A small knob a short distance west of milepost 644 is of rhyolite, like the knobs east of Siam and others farther north on the east side of the Iron Mountains.

This is the southernmost place at which Cambrian fossils have been found and apparently the southernmost outcrop of the Paleozoic rocks in this region.

between Bengal and Amboy, at an elevation of 613 feet, a descent of 1,975 feet from the divide east of Goffs. The origin of this basin has not been fully ascertained, but as the depression is completely surrounded by a rock rim it can not be due entirely to erosion and probably has resulted from tilting of a portion of an old stream valley.

The bottom of the general basin consists of a series of broad saucer-like hollows or playas [1] in which lakes usually form when the rainfall is sufficiently heavy. Because evaporation is fairly rapid and the precipitation meager, these lakes soon dry, leaving their dissolved salts, such as sodium chloride and calcium sulphate, together with more or less fine sediment. These accumulations have been in progress for a long time, and there is now a thick body of them forming the floor of the basin. Sodium chloride (common salt) exists in large amount, and there is also considerable gypsum. These deposits are quarried extensively east of Amboy. At Saltus siding, near milepost 657, there is a salt refinery a short distance south of the railway, which ordinarily produces a car or two of salt a day. The salt is mined 4 miles farther south, in the lowest part of the basin, and brought by the company's railway to the works, where it is refined for market. The mining is done by open pits. The salt is covered by a few feet of sand, under which the nearly white rock salt forms a pavement of wide extent. It is in several layers, separated by thin deposits of silt, and from 5 to 7 feet of it is taken out at most places.

The gypsum occurs in irregular bodies, one of which crops out along the railway from milepost 657 nearly to Amboy. It forms a white crusty surface with protruding lumps of harder masses of the mineral. A short distance north of the track, as well as at Amboy, it is covered by wash from the mountain slopes. Just south of milepost 659 there are extensive pits 6 to 8 feet deep in which the gypsum is obtained. It is carried by a small railway to the plaster mill at Amboy, where it is heated to expel the water and ground to the fine powder known as plaster of Paris.

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[1] A playa is a shallow, flat-floored depression, characteristic of valleys having no regular drainage to the sea, in which storm waters collect and evaporate. It may be a shallow lake or a salt-incrusted mud flat.

In his description of the ancient Lake Lahontan, in Nevada, Russell writes:

"The scenery on the larger playas is peculiar and is usually desolate in the extreme but is not without its charm. In crossing these wastes the traveler may ride for miles over a perfectly level floor, with an unbroken sky line before him and not an object in sight to cast a shadow on the ocean-like expanse. Mirages, which may be seen almost every day on these heated deserts, give strange fanciful forms to the mountains and sometimes transfigure them beyond recognition. A pack train crossing the desert a few miles distant may appear like some strange caravan of grotesque beasts fording a shallow lake, the shores of which advance as one rides away. The monotony of midday on the desert is thus broken by elusive forms that are ever changing and suggest a thousand fancies which divert the attention from the fatigues of the journey. The cool evenings and mornings in these arid regions, when the purple shadows of distant mountains are thrown across the plain, have a charm that is unknown beneath more humid skies, and the profound stillness of the night in these solitudes is always impressive."

Amboy.

Elevation 614 feet.
Kansas City 1,583 miles.

Amboy is dependent on the plaster mill and a few mines in the mountains. A stage line which runs to Dale, a mining camp 45 miles to the south, crosses the lowest part of the basin near the salt deposit and goes through a pass or depression in the Sheep Hole Mountains, which are about 11 miles distant. These mountains consist of granite and schist of pre-Cambrian age and form a part of the topographic barrier of granite and other igneous rocks which borders the south side of the valleys traversed by the railway as far as Barstow.

The Marble Mountains, constituting the north rim of the basin a few miles north of Amboy, consist mainly of coarse-grained granites, mostly light gray, penetrated by large bodies of dark coarse-grained quartz monzonite. Many masses of limestone altered to white marble occur north and northeast of Amboy. At one locality 4 miles north of Amboy considerable iron ore has replaced the limestone near the igneous contact. In the foothills of this range 2½ miles north of Amboy there is a low ridge of light-colored lava (rhyolite), and a short distance northwest of this a large rounded hill of fine-grained, dark-colored rock (diorite), probably much older than the lavas. A mile east of these knobs is a small pit in light-colored clay which has been used for mixing with the plaster at the Amboy mill. This clay is probably part of the mass of earlier sediments that underlie the valley and are here upturned along the foot of the mountain rim. A 700-foot well in Amboy is reported to be entirely in sand and gravel and to have yielded only salt water, which occurred in considerable volumes, especially near the surface. At a depth of 70 feet it penetrated a deposit of gypsum.

Summer temperatures in this part of the desert are very high, those at Amboy often exceeding 120° F. However, the mean annual temperature at Amboy is much less than that of places at lower altitudes farther south within our borders, a maximum of 130° having been recorded at Salton, in the Colorado Desert. The rainfall in the desert region of southeastern California to Barstow and beyond is very small, averaging only about 5 inches a year. West of Amboy the train passes a series of rather recent volcanic cones and lava flows.

In the center of the basin, not far southwest of Amboy, there is a fine cinder cone on an extensive sheet of black lava (basalt). This lava is, geologically, very recent and may have flowed out over the bottom of the basin within the last thousand years. It covers a nearly circular area about 5 miles in diameter. Its surface is remarkably rough, being covered with large blisters, most of them broken, and it has many caverns where the hot lava has run out at lower levels as it congealed at the surface. All the rock is black, practically unchanged by weathering, and full of vesicles or small holes, due to the escape of steam carried by the molten lava. The edge of the sheet is irregular, just as the lava congealed at the margin of the flow. At milepost 664 the railway is at the north edge of the lava, which it follows for a mile or more to the west, affording an exceptionally interesting and instructive view of the flow and cone. The cone, which is near the center of the flow, about 2 miles south of milepost 664, is about 200 feet high. It consists of a pile of black or dark-gray cinders or pumice, with a large crater in the center. In its southwest side there is a deep breach, from which extends a thin later sheet of lava that flowed out over the main sheet. This accumulation of cinders marks the later stage of the eruption, when the vent sputtered out a shower of cinders and fragments of lava frothing with steam bubbles. At the same time there were ejected occasional bombs of more or less completely consolidated lava, which are now embedded in the cinder. This volcano and the one at Pisgah, 43 miles farther west, are exceptionally good examples of a modern lava flow, and many features of both are visible from the train. The structural relations of flows of this character are shown in figure 38.

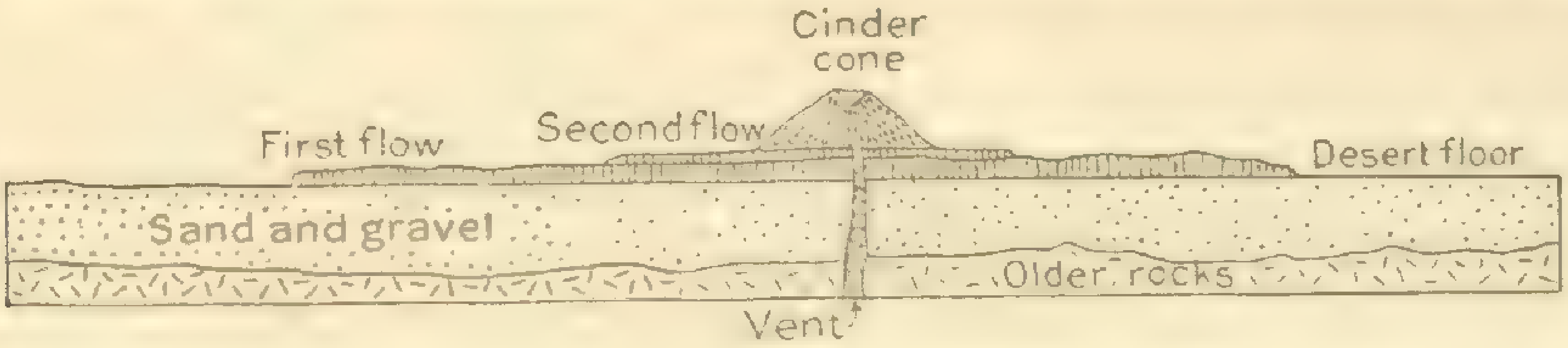

FIGURE 38.—Ideal section through a recent lava field and vent.

From Amboy to Bagdad the railway line begins to rise gradually on the west slope of the basin.

Bagdad.

Elevation 787 feet.
Kansas City 1,590 miles.

All trains stop at Bagdad for water and fuel oil. The water is brought daily on a train of 20 tank cars filled from springs at Newberry, 56 miles to the west. Deep borings at Bagdad and at other points in the basin have obtained only salt water.[1] A short distance north of Bagdad is a low ridge which extends far to the northwest. It consists of dark massive igneous rock (quartz monzonite), overlain by volcanic tuffs and sheets of lava (rhyolite). About 9 miles north of Bagdad are the Marble Mountains, already mentioned. In this range is located the Orange Blossom mine (in granite aplite), which has yielded copper ore carrying more or less gold.

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[1] In preserving for the traveler the water supply of this desert country the cactus plays an interesting part. The roots of this distinctly American plant extend widely, for the most part at 2 to 4 inches below the surface, so that they suck up a quantity of water from the soil very quickly after a rain. Once stored in its tissues, this water is retained by the cactus with great tenacity. Water

South of Bagdad there is a desert plain 8 miles across, partly filled on the east with the lava sheet. West of this sheet the flat contains salty and gypsum-bearing deposits, mixed with more or less fine sand. This is the west end of the basin which contains the salt and gypsum east and south of Amboy but which, just west of Amboy, is floored with lava. On the south side of the basin rises a prominent ridge of volcanic rocks of supposed Tertiary age, consisting of agglomerate and tuff associated with large bodies of light-colored lavas (latite and rhyolite). An old lead-silver mine in this range has produced considerable high-grade ore from a vein that is exceptionally well exposed at the surface. Three miles farther south is the high range known as the Bullion Mountains, which consists of igneous rocks of various kinds.

West of Bagdad the train begins to climb rapidly out of the basin along the slopes of cinder cones and masses of black lava (basalt) lying on older granitic rocks. Halfway between mileposts 672 and 673 a small black hill south of the railway is evidently the remnant of a cone or larger mass of basalt. Near milepost 674 there is in view just north of the track a large cone made up of inclined beds of reddish cinder.

Another similar cone is also visible a few miles farther northeast. As the train ascends the slope to the north it approaches hills and ridges of volcanic tuff and ash, overlain in places by flows of basalt. A mile south of milepost 678 several small, low black knobs rise out of the desert plain, probably the remnants of an old crater or a flow of lava (basalt), considerably eroded and buried by sand and gravel. West of Siberia siding the railway makes some long, sweeping horseshoe curves in rising on the slope of the basin. These curves give fine views back into the wide basin, in which the cinder cone near Amboy is a prominent feature. At Klondike siding (milepost 682)

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absorbed by plants is evaporated through their green surface. Most of the cactuses have leaves, but as a rule the leaves are minute or even microscopic, and the structure of their cells is such as to hinder transpiration and conserve the water stored. In the walls of the cells are thin sievelike places which permit the easy passage of water from one cell to another throughout the interior. A barrel cactus was found to contain 96 per cent of its weight of water. The water contained in cactuses is often palatable, but not invariably so. It is interesting to note that those in which the water is nauseous are less protected by spines than those whose juice is sweet and tempting. In experimenting with desert mice it was found that they will not drink water, a fact which suggests that they secure moisture from the plants they consume, or possibly they have a special means of separating moisture from the air. The spines of the cactus are straight or curved, hairy or feathery, and grouped in starry clusters or in rows. They have been used for fishhooks, needles, and combs and in various other ingenious ways by the primitive tribes. The flowers of the cactus vary in form, and most of them are extremely beautiful. The different species display brilliant tints of purple, yellow, orange, and rose. Some open by day; others by night. Many of the species bear edible fruits, and the seeds of some are used by the Indians for food.

an altitude of 1,652 feet is attained. To the northeast are hills of volcanic tuff and ash, and one long butte capped with black lava (basalt). To the southwest is a group of hills of tuff with bodies of light-colored lava (rhyolite), which extends for some distance west.

At milepost 684 the railway is just south of hills of volcanic tuff, capped with basalt, and just south of the track is the end of a lava flow at a lower level, upon which the train runs within a short distance. At the next milepost the lava of this flow is exposed in railway cuts. It occupies a saddle or wide valley which extends westward past Ash Hill siding. Here the train passes over a divide (altitude 1,944 feet) in a depression between the hills, to the north and south, which rise a hundred feet higher. The entire surface of the divide, as well as the adjoining slopes, is covered with a lava flow (basalt) of relatively recent age though not nearly so recent as the one in the basin near Amboy. The lava extends down the west slope also nearly to Ludlow; its source was probably in the hills north of Ash Hill siding, but no evidence of a crater was noted in that area.

Ludlow.

Elevation 1,779 feet.
Population 255.*
Kansas City 1,614 miles.

The Tonopah & Tidewater Railroad runs north from Ludlow (see sheet 23, p. 162) to Goldfield, Nev., noted for its rich gold mines, and a small branch road goes south 10 miles to the Bagdad-Roosevelt mine. Ludlow is in the south end of another basin, which extends far to the north. For a long time this basin has been receiving the drainage of a wide area of surrounding hills, so that the thick deposit of silt and sand which it contains includes evaporation products as well. A deep boring (1,500 feet) at Ludlow and another (600 feet) 8 miles to the north penetrated many sand beds containing water, but all the water carried so much salt that it could not be utilized. The water for town and railway consumption is brought from the spring at Newberry by a daily train of tank cars. A short distance south of Ludlow are buttes and ridges of volcanic agglomerate and tuff containing sheets and intruded masses of light-colored lava (rhyolite).[1]

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[1] Nine miles south, at the Bagdad-Roosevelt mine, there are ridges of older igneous rocks (mainly monzonite porphyry and latite). A sheet of breccia of considerable extent at this place carries gold and also in places rich copper ores, which have been extensively mined. This ore-bearing breccia is a rhyolite porphyry crushed into fragments and cemented together by silica. Its relations are clearly exposed in outcrops and some of the shallower workings. Northwest of Ludlow there is a high rugged range known as the Cady Mountains, consisting of bright-colored volcanic tuffs and lavas (rhyolite), in large part of green, brown, and buff tints. This series also constitutes the hills and ridges northeast of Ludlow, but farther north, near Broadwell station on the Tonopah & Tidewater Railroad, high ranges of light-colored granite stand on both sides of the basin. Thirteen miles northeast of Ludlow volcanic tuffs capped by black lava (basalt) are exposed, abutting against granite in the slope of the higher ridge on the north.

The bottom of the basin a few miles north of Ludlow usually presents a vast expanse of glistening, mud-cracked surface, but sometimes it is covered by water. This bare plain is in conspicuous contrast to the general area of the desert, which is covered with the creosote bush (*Covillea tridentata*).

Ludlow is the outlet for the Death Valley borax, now carried by rail but formerly by the well-advertised 20-mule team. One of the wagons used in this transportation is now on exhibition on the north side of the track a few rods beyond the station. Its capacity is 10 tons.

West of Ludlow the train climbs rapidly along the slopes of buttes of volcanic rocks (rhyolite and tuff), which rise to considerable height in a series of ridges extending far to the south. These rocks are well exposed at Argos siding, 5 miles west of Ludlow.

At a point 1.4 miles west of Argos, just beyond milepost 700, the train crosses a low divide and enters another basin. The bottom of the basin is largely occupied by a very recent sheet of lava,[1] the edge of which is half a mile beyond milepost 701. The railway skirts the northern edge of this lava flow for 6 miles, or to a point a short distance beyond Pisgah siding. Near the center of the flow, about 2 miles southeast of Pisgah siding, rises a beautifully symmetrical cinder

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[1] The lava is black and cellular, and although the sheet is not very thick it presents a surface of extreme irregularity, closely resembling some of the most recent flows in other portions of the world.

As in the other recent flows, the lava welled out of an irregular orifice and spread widely over the bottom of the basin. As its area widened the surface congealed, but the hot lava broke out from underneath, causing tunnels and irregular caved-in areas which are typical. That the molten lava was filled with steam is shown by the scoriaceous or honeycombed character of the rock. Many of the details of flow are clearly shown by the surfaces, which in some places are ropy, as the lava puckered in congealing, and in others are glassy and smooth, like slag from a blast furnace. Many of the tunnels are extensive, and there are also innumerable huge bubbles or blisters, more or less cracked by deep fissures due to the contraction caused by cooling. The margin of the flow presents an irregular edge of low cliffs, in most places consisting of great masses of broken fragments, formed as the congealing rock was pushed along by the advance of the flow.

The cinder cone was built up at the end of the eruption and undoubtedly marks the place of the orifice. In its last stages the action was mainly a violent escape of steam, which blew out a large amount of cindery or pumiceous material, together with occasional hardened masses of lava. This was all thrown to a considerable height in the air, and, falling on all sides, quickly built up a cone. A mass of cinder lying against the west inner side of the cone is slightly different in color, and probably is the product of a final supplemental outburst.

The recent date of this cone is indicated by the fact that the pile of loose material has not been affected by the powerful erosive processes of the region, and there is no perceptible oxidation of the rocks or cinders. The lava still shows the jagged edges due to accidents of flow, and there are many minute stalactites of lava hanging in the roofs of the tunnels. The material also overlies and abuts against sand deposits that are of recent age.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
SANTA FE ROUTE
From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

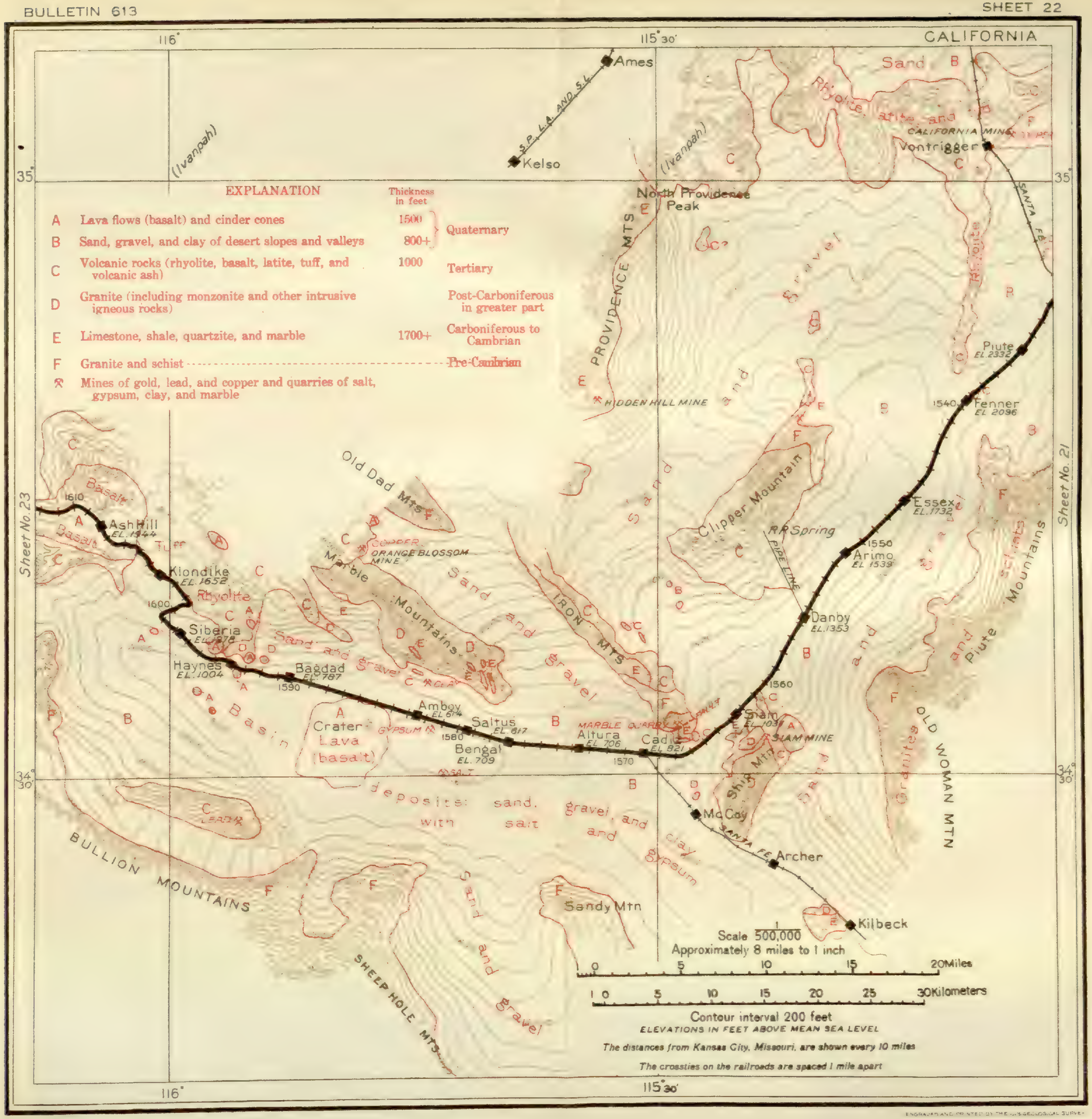
UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist
R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.



cone about 250 feet high, with a large, deep crater in its summit. This cone, which is usually called Mount Pisgah, is as fine an example of a recent volcanic outflow as can be seen anywhere. Some of its features are shown in Plate XL (p. 151).

The mountains which rim the basin north and south of Pisgah siding consist mostly of granites, the thick mass of volcanic tuffs and lavas constituting the southeast end of the Cady Mountains northwest of Ludlow apparently having ended at a point northeast of Pisgah. From Pisgah to Troy, a distance of 12 miles, there is a down grade of 368 feet into the basin.

North and south of Hector there are low hills of Tertiary volcanic tuff. The western extension of the lava sheet from Mount Pisgah lies some distance south of Hector, but it is approached and crossed by the railway between Hector and Troy.

At Troy siding the basin opens out westward into a broad flat that extends to Mohave River, about 7 miles to the north. The plain here is remarkably smooth, and it is covered in part by silt and in part by low sand dunes. In an area of considerable extent about Troy there is a large volume of fairly good water only a short distance below the surface, and it rises within 4 feet of the surface near the siding. On account of this supply a number of settlers have recently taken homesteads in this flat, expecting to pump the water for irrigation. At most places here the water does not carry very much salty material, for this part of the valley drains into Mohave River, and salts appear not to have accumulated in it.

A short distance northeast of Troy is a range of low hills consisting of volcanic tuff and lavas (rhyolite and basalt), which bear off northwestward to Mohave River. These materials probably also underlie the flat, for they appear in a number of low knobs to the west, south, and southeast of Troy. The larger mountain mass, 5 miles south of Troy, however, consists of light-colored granite (quartz monzonite). A very thick deposit of bowlders and gravel lies against these granite slopes, constituting high hills of rounded form. In one area of considerable extent these gravel beds are surmounted by a flow of black lava (basalt),[1] which caps a high mesa clearly discernible south-southwest of Troy.

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[1] This lava came from a cinder cone at high altitude behind the main granite range and flowed to the north and northwest down a valley of moderately steep slope. Its irregular termination 4 miles southwest of Troy is not very high above the level of the railway. A portion of the northern rim of this old valley in the higher slopes 6 miles south-southwest of Troy has since been cut away by erosion, so that part of the black edge of the upper portion of the flow is now visible from Troy.

Newberry.

Elevation 1,831 feet.
Kansas City 1,647 miles.

Newberry siding, 6 miles west of Troy, is notable for the great spring which issues from the volcanic tuff at the foot of the mountain a short distance southwest of the station. The water is piped to the station, pumped into tanks, and used for railway and residents as far east as Bagdad, an interval in which no good local water is obtainable. For this service the operation of a daily train of 20 tank cars, holding 10,000 gallons each, is required. This spring is supplied by rain water which sinks underground in crevices on the mountain slope and finally accumulates in some main joint plane which extends to an outlet at the foot of the range.

North of Newberry is a wide flat extending to Mohave River, the course of which is indicated by a line of mesquite trees plainly in view from the train. These trees are always indicative of the proximity of water, although in some localities the supply is deep underground and in but small volume. They occur in considerable numbers about the spring at Newberry and on the flat near Troy, where the water is so near the surface. To the south is Newberry Mountain, a prominent steep ridge showing a thick succession of volcanic rocks (tuff, breccia, and rhyolite) dipping at a moderate angle to the southwest. These beds are probably the "Rosamond series," a formation characteristic of the borders of the Mohave Desert.

The Mohave Desert is a large quadrangular area of arid land lying north of the San Gabriel Mountains and southeast of the Sierra Nevada. Its eastern limits have not been exactly defined. The railway runs close to the southeast border of this desert between Barstow and Summit.

From Newberry to Daggett the country is nearly level, for the train traverses the broad river plain and gradually approaches Mohave River, which is but a short distance north of Daggett station.

Daggett.

Elevation 2,007 feet.
Kansas City 1,658 miles.

The village of Daggett serves as a source of supplies for numerous mines and a few ranches scattered along the valley. Here trains of the San Pedro, Los Angeles & Salt Lake Railroad, coming from the northeast, pass upon the Santa Fe tracks, which they use to Colton. Two miles north of Daggett the Calico Mountains, so named because of the bright variegated color of their slopes, rise abruptly from the north margin of Mohave Valley. They consist of a thick succession of beds of ash and other fragmentary materials thrown out of volcanoes and sheets of light-colored lava (rhyolite), dipping at a moderately steep angle to the east. On the south slope is the Calico mine, which has been a large producer of silver. On the east side of the Calico Mountains the volcanic series includes clays containing colemanite,[1] a crystalline borate of lime. These clays have been mined extensively for the production of borax. For many years large amounts of this material were treated at a refinery in Daggett, but the working of deposits of purer mineral in other areas has forced this refinery to cease operations. The "borax mines" are not visible from the railway except possibly by a very distant view to the northwest from Newberry.

South of Daggett is a broad range of rounded hills which rise steeply from the valley. Canyons among them reveal thick deposits of gravel and sand, in part cemented into conglomerate. Beds of volcanic tuff and ash are also included in these deposits.[2]

From Daggett to Barstow the train ascends the valley of Mohave River along its south side and in places follows the bank of that stream. For much of the year the water does not flow as far down as Daggett, but sometimes after a heavy rainfall the river bed is filled from bank to bank. The Mohave is one of the largest of the so-called lost rivers of the desert provinces. It rises on the north slope of the San Bernardino Range, flows northward for about 50 miles, to Barstow, and then, east of Daggett, turns eastward into a stretch where it ceases to flow except at times of high flood, when it ultimately reaches Soda Lake, or the sink of the Mohave, just south of the Amargosa drainage basin. Mohave River is in sight of the railway all the way from a point near Newberry to a point south of Victorville.

Near milepost 745, about 4 miles west of Nebo siding, the river valley is narrowed by high buttes of reddish lava (rhyolite) and other rocks, and bends considerably to the north around a ridge projecting from the south. Recently a deep cut, a mile in length, has been excavated through this ridge for the railway. The principal materials exposed in this cut are gravels and sands deposited by Mohave River a long time ago. In the central part of the cut a red lava (rhyolite) is reached, and the gravels and sands are exposed abutting against slopes of the lava, which rises to the surface in prominent buttes not far north and also constitutes several small knobs along the river bank from this place to Barstow.[1]

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[1] Colemanite contains 50.9 per cent of boric acid, 27.2 per cent of lime, and 21.9 per cent of water. The deposits near Daggett are believed to have been formed by replacement of limy beds that were laid down locally during the evaporation of lake waters of Tertiary time, in intervals between some of the great outbursts of volcanic ejecta, which formed so large a part of the Tertiary deposits. The boric acid was undoubtedly derived from fresh volcanic materials and carried to its present position by underground waters. The deposits are in two principal beds, each 5 feet thick and about 50 feet apart. These beds dip steeply and have been mined to a depth of 500 feet. All the borax produced in the United States is obtained from California mines, mainly from Lang, north of Los Angeles and Death Valley. The value of borate ores in 1913 is estimated at nearly $1,500,000. The borax is produced by heating the pulverized colemanite with a solution of sodium carbonate, forming the soluble sodium borate, which crystallizes.

[2] At the base of this series is a coarse breccia which, in the canyon 6 miles south of Daggett, is underlain by granite. It contains large fragments of various igneous rocks and also of the underlying granite. Farther southeast it includes many fragments and bowlders of dark fine-grained rock (basalt), evidently derived from Ord Mountain, a high ridge 14 miles southeast of Daggett. In the northwestern slope of this mountain there are mines of copper ore carrying gold.

Barstow.
Elevation 2,106 feet.
Population 1,066.*
Kansas City 1,668 miles.

Barstow owes its existence mainly to railway and mining trade. It is a railway division point where the line to San Francisco, by way of Bakersfield, diverges from the line to San Bernardino, Los Angeles, and San Diego. A spacious hotel is located here under the title of Casa del Desierto (house of the desert). The valley of Mohave River is narrow at Barstow. There are two prominent buttes of red lava (rhyolite) in the southern part of the town, and ridges consisting of volcanic tuff interstratified with sheets of lava rise a short distance north of the river. A small but very prominent butte of red lava (rhyolite) stands in the center of the valley just north of Barstow station.

The railway, which has run north of west for 100 miles beyond Cadiz, here turns southward toward Cajon Pass and San Bernardino. After leaving Barstow[2] the train continues to follow the south or east bank of Mohave River past Todd, Hicks, Wild, Helen, and Bryman to Oro Grande and beyond. The low flat along the stream is not wide, but most of it is utilized for irrigation at numerous ranches. The long slopes adjoining the river flat consist of gravels and sands apparently underlain at no great depth by volcanic rocks.

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[1] The sedimentary rocks of this region comprise about 3,000 feet of beds of middle Tertiary age. They lie on a somewhat irregular surface of granite and gneiss and are very much flexed and faulted. Three general divisions are recognized. The lowest, 1,200 feet or more thick, is mostly fine tuff and volcanic ash, with thin lava flows and at the base some sandstones, in large part conglomeratic. It weathers into irregular hills in which brown, gray, greenish-yellow, and purplish shades prevail. The middle division, 1,500 feet or more thick, is made up of pale-greenish clay, with thin beds of sandstone, ash, and limestone, and at the base a deposit of coarse granite fragments in places cemented into breccia. The top division consists of loose beds of angular rocks, fine gray ashy sand, and clay, forming round buff-colored hills. It contains abundant fossil bones of extinct species of horses, camels, and other mammals believed to be of later Miocene age, some of them the same as the bones found in the Santa Fe marl. The Tertiary rocks cropping out along the north side of Mohave River from Daggett to Barstow are fine sands and clays, with thin interstratified limestones and volcanic rocks. A dark rocky ridge of tuff and volcanic flows comes to the river a short distance west of Daggett. The rocks in the knobs immediately about Barstow are rhyolite, but clay and limestone appear not far north and granite and schist crop out to the northwest and to the northeast.

[2] Mileposts to Los Angeles indicate the distance from Barstow.

DEPARTMENT OF THE INTERIOR

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
SANTA FE ROUTE
From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

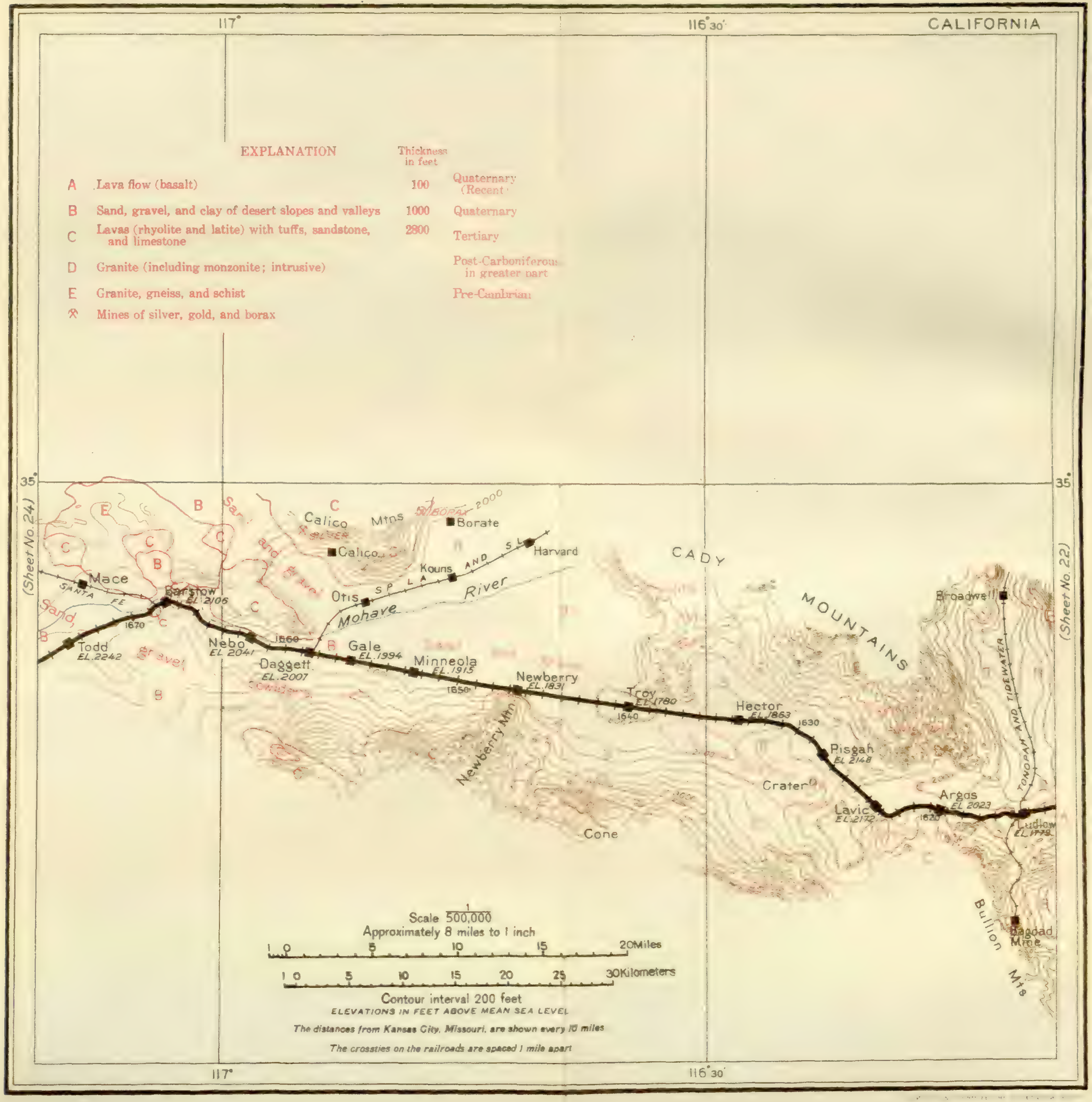
UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist   R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.


CALIFORNIA
117°
116°30'
35°
EXPLANATION
Thickness in feet
A Lava flow (basalt) 100 Quaternary (Recent)
B Sand, gravel, and clay of desert slopes and valleys 1000 Quaternary
C Lavas (rhyolite and latite) with tuffs, sandstone, and limestone 2800 Tertiary
D Granite (including monzonite; intrusive) Post-Carboniferous in greater part
E Granite, gneiss, and schist Pre-Cambrian
⚒ Mines of silver, gold, and borax
(Sheet No. 24)
(Sheet No. 22)
Calico Mts
Borate
Calico
Harvard
Kouns
Otis
Mohave River
CADY MOUNTAINS
Broadwell
Mace
Barstow EL. 2106
SANTA FE
Sand
Todd EL. 2242
Nebo EL. 2041
Daggett EL. 2007
Gale EL. 1994
Minneola EL. 1915
Newberry EL. 1831
Newberry Mts
Troy EL. 1780
Hector EL. 1863
Pisgah EL. 2148
Crater
Lavic EL. 2172
Argos EL. 2023
Ludlow EL. 1779
TONOPAH AND TIDEWATER
Cone
Bullion Mts
Bagdad Mine
1670
1660
1650
1640
1630
1620
2000
Scale 1/500,000
Approximately 8 miles to 1 inch
0 5 10 15 20 Miles
0 5 10 15 20 25 30 Kilometers
Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart

South of Hicks (see sheet 24, p. 178) hills of various kinds of rocks border both sides of the valley. To the west are ridges consisting of beds of fragmental materials ejected from volcanoes, with some lava flows in their higher portions. The low ranges southeast of Hicks consist of granites and diorites, the former apparently in dikes penetrating the latter. South of milepost 15 are two prominent buttes of coarse-grained massive light-gray granite.

Hicks.

Elevation 2,278 feet.
Kansas City 1,680 miles.

Granite is exposed in a small cut on the railway near milepost 17, a few rods north of Wild siding, and a short distance farther west a small knoll of the same rock rises from the river flat just west of the tracks. At milepost 18 and for a mile and a half southwest of it there are cuts in gravels and sands which are part of the alluvial filling of the valley, deposited long ago by Mohave River. Beds of fine-grained material cropping out at the base of these deposits are probably somewhat older still and mark another period of deposition by a stream flowing across the region. At milepost 20 is another small cut in dark granite which underlies the gravels along the east bank of the river.

East of Helen siding a group of buttes and hills of moderate elevation lie a short distance southeast of the railway. They consist of a peculiar fine-grained light-colored lava (rhyolite) intersected by some small masses of dark rock (hornblende diorite), either in dikes or inclusions. This lava extends several miles to the southeast in hills and ridges of moderate height. Some portions of it are completely decomposed to white kaolin,[1] and material of this sort 4 miles east of Bryman is worked extensively to supply "chalk" works at Bryman. The product, being of pure white color and very fine grain, is used for various purposes.

At Oro Grande (Spanish for big gold) there is a large Portland cement plant. Here Mohave River contains water nearly all the year, and it is used for the irrigation of various crops in a narrow strip of bottom land. East of the town is a high ridge consisting of granite, marble, schist, and hard sandstone.[2] The marble is used in the manufacture of cement at the plant in Oro Grande. It is quarried at several large openings half a mile east of the railway.

Oro Grande.

Elevation 2,635 feet.
Population 70.*
Kansas City 1,699 miles.

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[1] This kaolin results from chemical changes due to weathering, in the course of which feldspar, one of the component minerals of the rhyolite, loses alkali by leaching, a large proportion of claylike aluminum silicate being left behind, together with more or less quartz and other minerals which are in the form of hard grains. After thorough mixing with water, the fine aluminum silicate or kaolin is floated off and deposited in tanks, leaving the granular constituents behind.

[2] The structure of the ridge east of Oro Grande is complex, for the beds are bent and broken and cut by great masses of granite (quartz monzonite) which have been intruded through limestone, shale, and sandstone, the resulting heat and pressure altering these rocks to marble, mica schist, and quartzite. The high central peak and several lower ones consist of very hard quartzite, and the hills on the south side of the range are of granite.

The plant also uses a small amount of schist and the decomposing granite. These rocks are ground, mixed in proper proportions, and melted into a clinker, which, when pulverized finely, forms Portland cement. Portions of the marble are so nearly pure calcium carbonate that they are suitable for calcining into lime for use in beet-sugar manufacture, and a large amount of it has been obtained for that purpose from quarries about a mile east of Oro Grande.

Granite extends west to the river bank and railway half a mile beyond milepost 32, or nearly a mile beyond Oro Grande. At the railway bridge across Mohave River at milepost 34 it constitutes the walls of a canyon through which the river flows for 2 miles. In slopes east of the bridge are conspicuous exposures of the granite cropping out in bare ledges, appearing like a great pile of huge bowlders and slabs. This rock is quarried extensively for building stone at several places southeast of Oro Grande. It is a handsome and durable material, easy to dress, and uniform in color.

For several miles beyond milepost 34 the railway follows the foot of a high bank of sand and gravel, much of it in regular, horizontal layers. This material constitutes a flat-topped river terrace; it was deposited by Mohave River at an earlier stage of the development of the valley and of the terrace plain, which extends far to the west. The sand and gravel continue along the west side of the track for several miles, but the best exposures of the beds are near milepost 36. Across the river east of this place are numerous rocky ridges ending in a small knob near the river. These ridges consist mostly of granite, but some of the more distant ones include also large masses of white and variegated marbles which have been quarried for building stone.

Victorville.
Elevation 2,716 feet.
Population 580.*
Kansas City 1,704 miles.

Victorville is an old settlement that has grown gradually as headquarters for mining, quarrying, and ranch interests in the surrounding region. Above and below the town there are many ranches that use the river water for irrigation. A short distance south of Victorville the river passes through a short narrow canyon of the granite, with walls about 150 feet high. The railway is built on the west bank of the river, partly on an embankment and partly on a shelf cut in the rock. The canyon is due to a projecting ridge of the granitic rock which slopes down abruptly under the great sheet of sand and gravel which underlies the wide plain extending far to the west. The canyon is a gateway to a wide valley bottom with numerous ranches. Possibly some time a dam will be built in the canyon to create a storage reservoir that will extend some distance up the valley. Although the flow of the Mohave in the dry season appears small, a large amount of water passes through this gap in a year, and heavy freshets sometimes occur. For several years the United States Geological Survey gaged the flow in the gap and the stream was found to have an annual volume of 68,000 acre-feet, or a mean of 95 cubic feet a second. One freshet carried 13,400 cubic feet a second but was not of long duration. The water of Mohave River is now used for irrigating about 15,000 acres, mostly in alfalfa, grain, and garden truck.

At milepost 39, 2 miles south of Victorville, the train leaves the bank of Mohave River and, entering a small valley, begins to climb the steeper part of the long ascent of about 1,000 feet toward the high mountain ranges which lie between the Mohave Valley and the coastal region of southwestern California. The course of the railway continues nearly due south. The slope, which is the southern edge of the Mohave Desert, consists of a thick succession of sheets of gravel and sand which extend far up the mountain sides and beyond the summit at Cajon (cah-hone′) Pass. Near milepost 42 the railway has risen above the bottom lands of the Mohave Valley, and from this point southwestward for 10 miles or more there are fine views of the great mountain ranges ahead. To the southeast and south, across the upper Mohave Valley, rise the San Bernardino Mountains; the ranges ahead and to the southwest are the San Gabriel Mountains. These two ranges come near together at Cajon Pass, which leads into a gap between them. Mohave River and many other streams deposited the sand and gravel of which the plain is built, but later they have cut deep valleys across it. The relations of this detrital deposit are shown in figure 39.

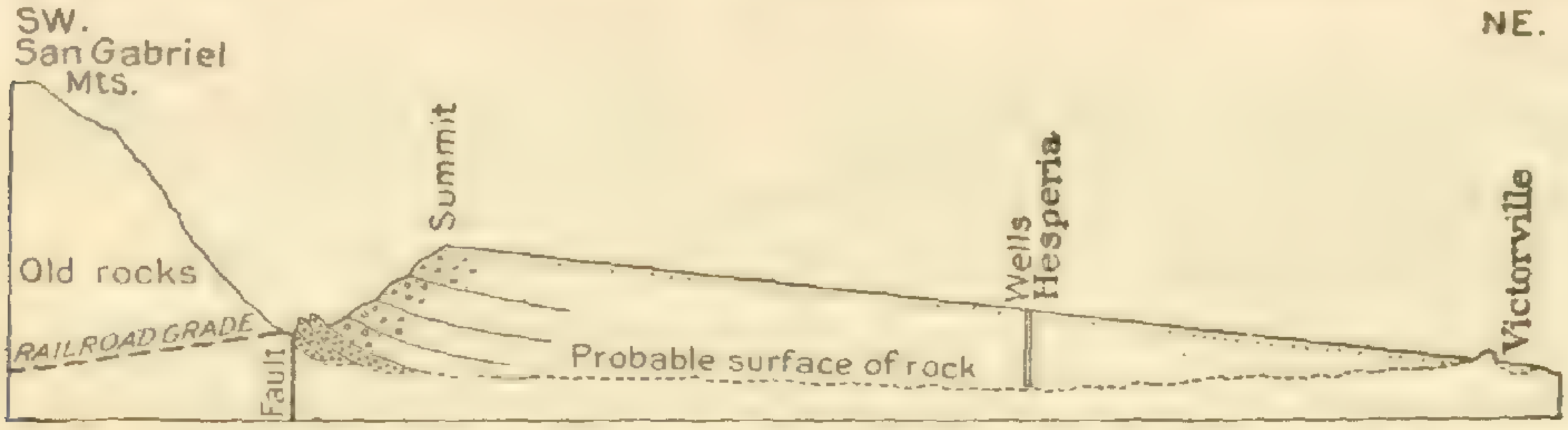

FIGURE 39.—Section through sand and gravel deposits of the sloping plain along the Santa Fe Railway north of the San Gabriel Mountains, near Victorville, Cal.

A peculiar yucca, locally known as the Joshua tree (*Yucca* or *Clistoyucca arborescens*) is conspicuous on the grade up the mountains. (See Pl. XLI, *A*, p. 168.) It begins with a few scattered trees below Victorville and becomes very abundant in the region about Hesperia and the slopes above, nearly to Cajon Pass, its upper limit being closely determined by the altitude and temperature. It is said that attempts have been made to utilize the fibrous trunk of the yucca for manufacturing paper, but the tree is now used chiefly in making souvenirs and trinkets.

Hesperia.

Elevation 3,189 feet.
Population 92.*
Kansas City 1,713 miles.

Hesperia is a small village that forms a trade center for ranches along Mohave River a few miles to the east and several ranches and orchards near by cultivated by irrigation. There are two of these irrigated orchards just southwest of the village, and another a mile farther south, on the west side of the railway. Some grain is also grown on the adjoining plain. Considerable water, which is being used for irrigation, is obtained from wells 500 to 800 feet deep.

Near Hesperia the creosote bush gives place to the Joshua tree and other plants suited to the higher altitudes. Between Hesperia and Summit there are many cuts in the thick body of gravel and sand constituting the great sloping plain.[1]

The traveler will note as he ascends the slopes that the bushes which are so widely scattered on the desert to the east and north become thicker and larger, and several new plants appear, notably the manzanita,[2] one of the most beautiful of the highland bushes, which forms a thick growth on the higher mountain slopes of this part of southern California. A far western variety of juniper (*Juniperus californica utahensis*) is also present, together with a peculiar piñon (*Pinus monophylla*) differing from the Arizona tree by bearing larger nuts and a single leaf. Its nuts have been an important food product for the Indians. The beautiful *Yucca whipplei* is conspicuous, with its straight stalks which in the early summer bear a great cluster of white flowers.

Summit.

Elevation 3,823 feet.
Kansas City 1,724 miles.

At Summit the railway reaches the top of the grade necessary to carry it through Cajon Pass, but the actual divide is in a cut a short distance west of the station. Cajon Pass is the great gap through the mountain barrier between the desert and the San Bernardino Valley, a gap occupied and drained by Cajon Creek and its tributaries. The train enters the pass proper as it descends from the divide on the edge of the desert into the valley of Cajon Creek. Beyond the summit cut the traveler gets a view of the deep valley of this creek, which crosses the main range and cuts deeply through its rocky ledges. Only a small branch of this stream heads near the summit, however, the valley proper heading a few miles west back of the San Gabriel Range, in a part of the slope that is considerably higher than the gap crossed by the railway. An outline map showing these relations is given in figure 40.

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[1] Near mileposts 50 and 52, where the railway ascends along the side of a small valley, the cuts are 30 feet deep and the gravels and sands are well exposed. Between mileposts 52 and 54 some of the gravel is consolidated into a loose conglomerate and the beds show a slight dip to the south, steeper than the upgrade of the plain. This feature indicates that there has been tilting of the crust of the earth in this region since the material was deposited. Near the mountains this dip is noticeable in many of the exposures. Between mileposts 55 and 56 there are some deep cuts in fine sand of buff color, with scattered beds and streaks of gravel.

[2] The manzanita (*Arctostaphylos patula*) is a shrub having a smooth bark of rich chocolate color, small pale-green roundish leaves, and berries that resemble diminutive apples. It is this resemblance that gives the shrub its common name, Spanish for little apple, by which it is known everywhere on the Pacific coast. Bears are very fond of these berries. The manzanita covers many of the hills in California with a stiff, almost impenetrable growth. Its wood is hard, and the blaze from an old gnarled root cheers many a western fireplace.

After passing through the deep cut west of Summit, the train follows a winding course, mainly to the west and southwest, along the side of steep slopes descending into the canyon of Cajon Creek. Along the railway grade descending from Summit there are many deep cuts through projecting spurs. These cuts reveal thick deposits of sand, gravel, and loose-textured sandstone which extend continuously northward into the Mohave Desert. These materials abut against the steep slopes of ledges of old rocks in the mountain ranges on the south, and beds apparently having a thickness of more than 2,000 feet are exposed in the descent from Cajon Summit to Cajon Creek. Cajon Creek flows east and south with sinuous course, finally running through a pass[1] between the San Bernardino Range on the

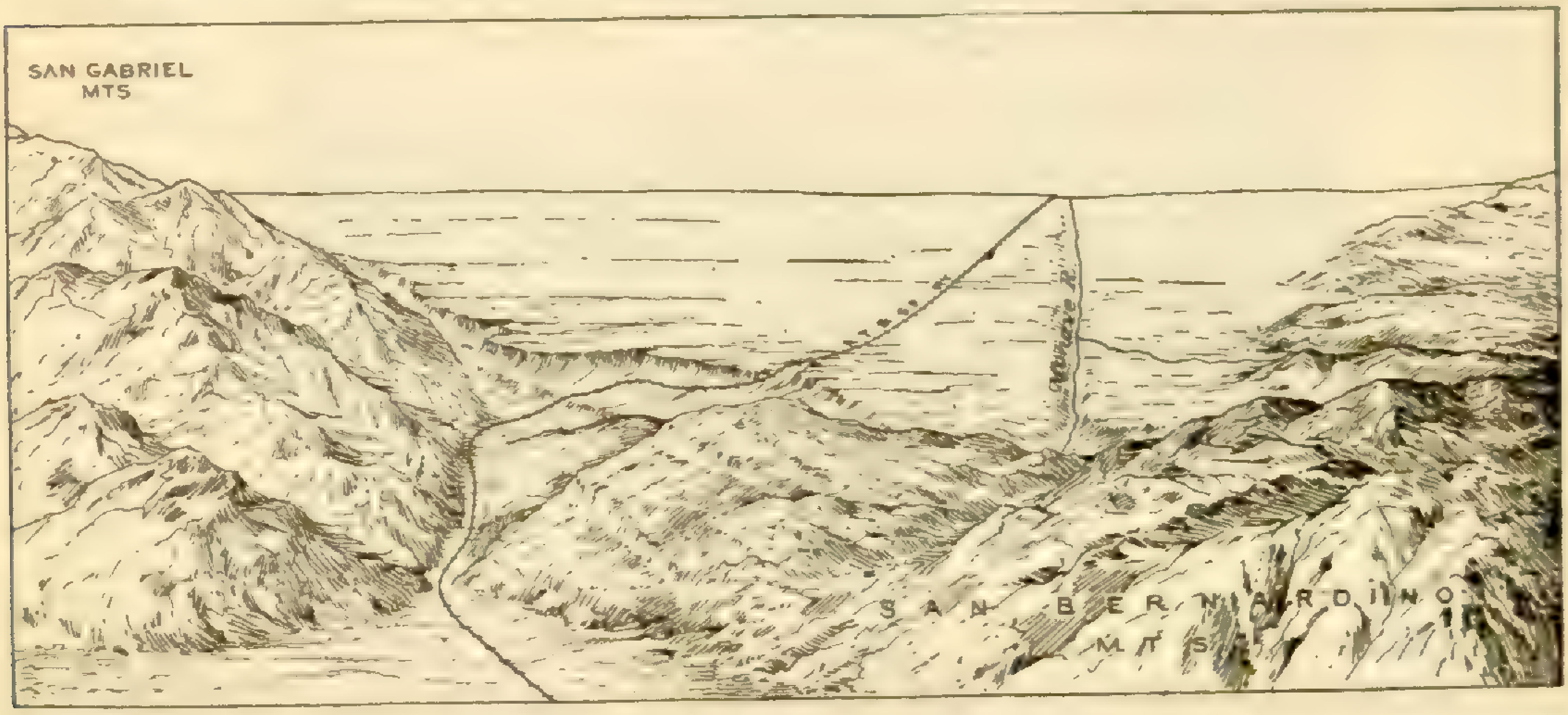

FIGURE 40.—Bird's-eye view of Cajon Pass and vicinity, California, showing the general features of configuration near the Santa Fe Railway.

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[1] This pass has been caused by a great fault or series of parallel faults of relatively recent age geologically, crossing the axis of the general mountain range extending across southern California. These faults, one of which is the southern extension of the San Francisco earthquake rift, extend for many miles along the south foot of the San Bernardino Range and on southward into the Colorado Desert. At the pass their northwesterly course crosses the mountains diagonally, so that to the westward they define the north side of the San Gabriel Range. There were several planes of movement not far apart with huge slivers or narrow blocks of schists and other rocks between them. The latest uplift apparently was on the northeast side, for the San Bernardino Range appears to be the most recently uplifted. Its central part presents wide, relatively level areas or remnants of plains in striking contrast to the eroded top of the San Gabriel Range.

east and the San Gabriel Range on the west, which affords an easy outlet into the great coastal plain or valley of southwestern California. It is 40 miles west to the next pass, and to the southeast of this gap mountains of considerable height extend for 200 miles continuously to Colorado River. Some of the most notable cuts, 60 feet deep, are near Dell siding, in one of which will be seen a remarkable framework several stories in height, designed to prevent the sand from washing and sliding into the cut.

Toward Gish the principal material is moderately compact, light-colored massive sandstone with conglomeratic streaks.[1] It contains many fragments of feldspar and quartz, evidently derived from granite.

Halfway between mileposts 64 and 65 the canyon narrows, turns south, and passes between steep ledges of hard, older rocks of the igneous and metamorphic series constituting the mountain ranges to the east and west.[2]

The mountain slopes are covered with bushes in considerable variety, in great contrast to the sparse vegetation on the Mohave Desert. The difference is due to increased moisture on the ocean side of the mountains.

Near milepost 69 the canyon of Cajon Creek widens into a valley bordered by mountainous slopes, but with a wide wash in its center and a broad sloping terrace at the foot of the mountains on the north side. This terrace is terminated by a steep slope or high bank at its foot, where Cajon Creek has cut into it, a feature which is conspicuous for 2 or 3 miles. As the valley widens, however, the cut bank ends and the slope blends with the general plain, which rises gradually to the rocky ledges at the foot of the mountain. These terraces and slopes consist of sand and gravel washed down from the mountains and deposited at their foot. On the terrace are several ranches with orchards of considerable size.

At Verdemont station the west wall of the canyon ceases as the mountain slope bears away to the west, and the railway is in the

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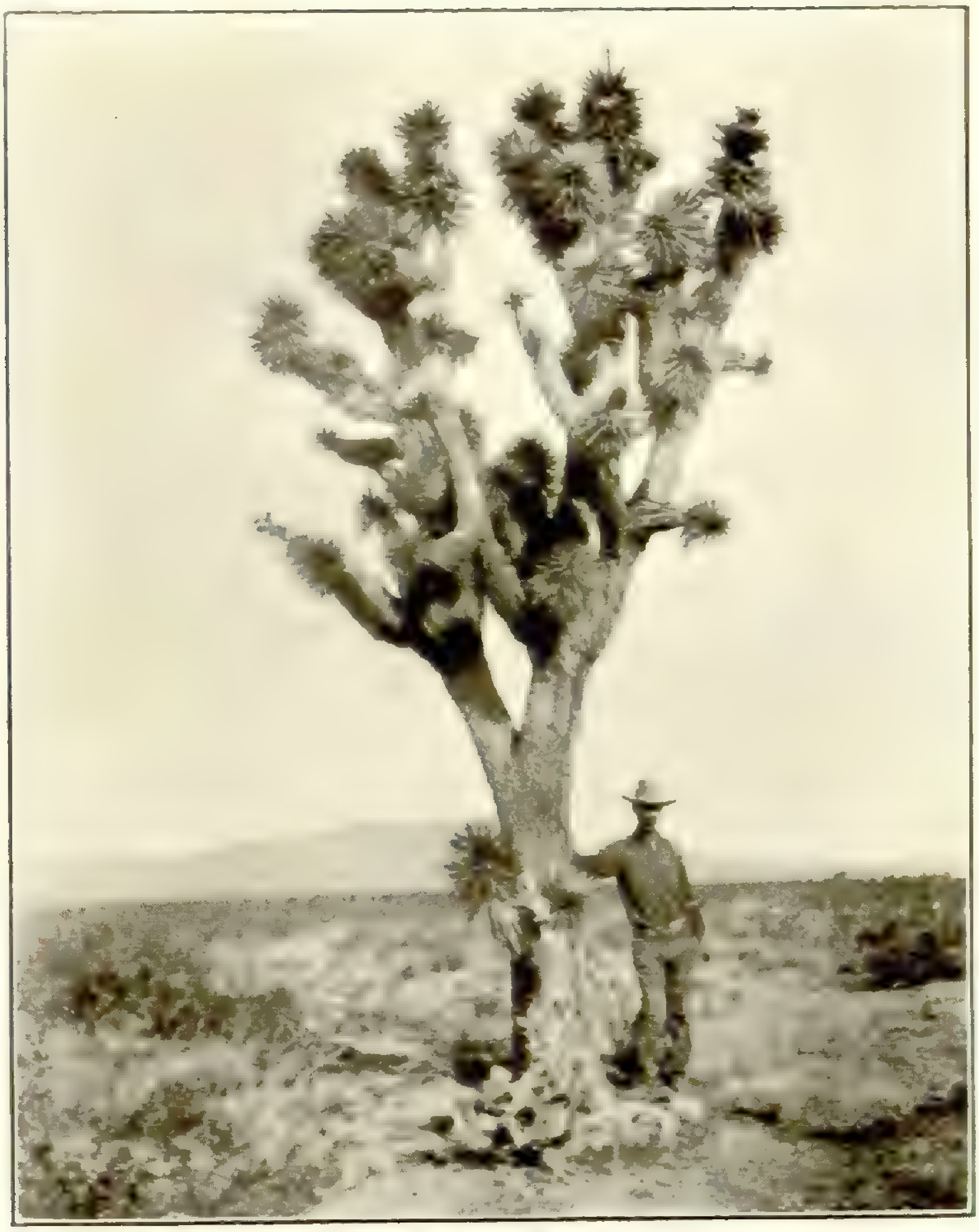
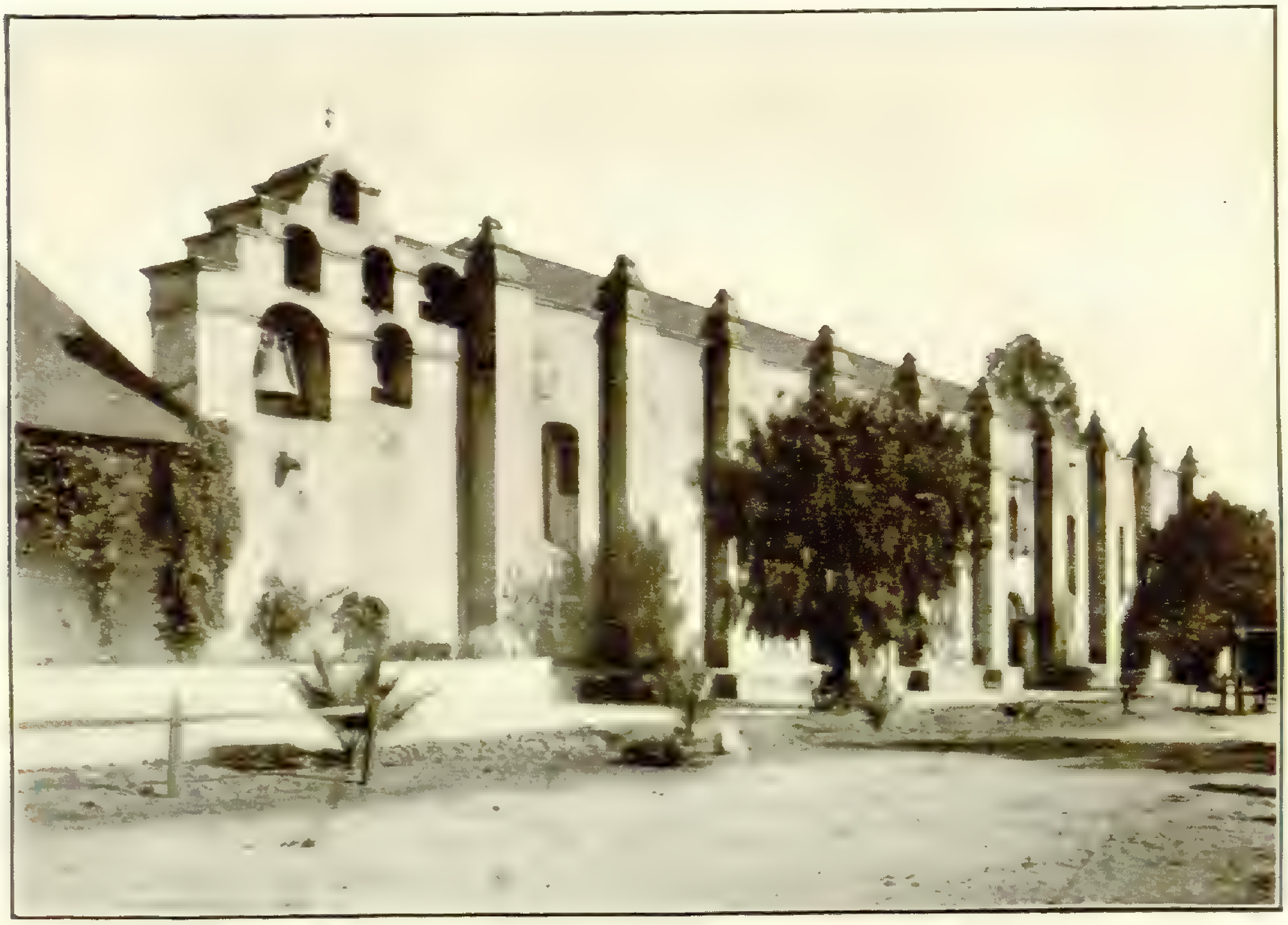
[1] Just west of Gish, along Cajon Creek, are many prominent ledges of this rock dipping to the northeast at an angle of 20° or more. As the valley of the stream is descended (on a southeast course) the ridges on each side show numerous outcrops of the lower beds of the sandstone series about Cajon siding, and for some distance beyond. In this vicinity the beds are more and more tilted up until they dip north, or away from the mountains, at an angle of about 30°. They are believed to be of Miocene age. The railway and the valley in this locality follow the line of the faults which cut across the range.

[2] Southward from this place these rocks appear extensively in the rocky slopes of the valley and they are cut by the railway grade at several points. The principal rocks are schists of greenish color. In places on the lower slopes of the valley there are remnants of narrow terrace deposits of gravel and sand, notably in cuts just beyond milepost 67, which is four-tenths of a mile beyond Keenbrook siding.



A. JOSHUA TREE.

A characteristic desert plant on the grade from Victorville to Cajon Pass, Cal.



B. SAN GABRIEL MISSION, CAL.

Founded by Padres Cambon and Somera under the direction of Fray Junípero Serra September 8, 1771.
Photograph furnished by Santa Fe Railway Co.

SAN BERNARDINO MOUNTAINS, CAL.

Redlands and its orange groves in the foreground. San Bernardino Peak in the center.

great San Bernardino plain, which is about 15 miles wide and 30 miles long, one of a series of the foothill valleys that border the southern edge of the San Gabriel Range for 90 miles. These valleys are filled with débris of unknown thickness, and their surface is made up of talus and wash from the adjacent ranges. The altitude here is 1,750 feet, and the distance to the ocean is about 50 miles. The valleys that extend to the coast lie between low ranges of granitic and other rocks. The chief of these ranges is the Santa Ana Mountains, which culminate in Santiago Peak, 5,680 feet high, and are visible on the southwestern horizon. A line of isolated hills of schist lies east of the railway for some distance beyond Verdemont, and another, which is crossed near Ono, rises into a ridge of considerable size north of milepost 78.

From Ono and beyond there is a magnificent view, to the northeast, of the San Bernardino Range (Pl. XLII), which includes many high summits. One of these, San Gorgonio Mountain, reaches an altitude of 11,485 feet, and not far west of it is San Bernardino Peak, which reaches 10,630 feet, or more than 9,000 feet above the valley land at the foot of the mountains. This high range extends far to the east but with diminished altitude and finally becomes the north side of the great desert basin in which Salton Sea is situated. At a time not far distant there were small glaciers in the higher parts of this range. From points near milepost 79 and beyond, there may be seen the remarkable scar, like a huge arrow point, on the mountain slope at Arrowhead Springs. This feature is not always conspicuous, its distinctness depending on light and foliage, but it can be discerned on close scrutiny. It is due to a peculiar-shaped area of bare rock ledges and thin vegetation. Here there is an interesting group of hot springs, some of which have temperatures exceeding 180° F. and about which buildings have been erected to form a popular health resort.

At Highlands Junction the main line is joined by a branch road known as the "high line," on which trains run frequently to Redlands and other points east of San Bernardino.

San Bernardino.
Elevation 1,078 feet.
Population 12,779.
Kansas City 1,749 miles.

One other transcontinental railway, the San Pedro, Los Angeles & Salt Lake, passes through San Bernardino over the Santa Fe tracks, and another, the Southern Pacific, goes through Colton, 3 miles to the south. This city is the seat of San Bernardino County, the largest county in the United States, having an area of slightly more than 20,000 square miles, or almost equal to that of Massachusetts, Connecticut, and New Jersey combined.

San Bernardino is built over a wide area of the plain, about 5 miles south of the foot of the San Bernardino Mountains. It is an old settlement, dating back to the Spanish occupancy of southwestern

California, but in the last 20 years or so it has grown into a large modern city with many industrial interests. About 15,000 acres of land in the surrounding region within 5 miles is under cultivation, mostly by irrigation. Much water is obtained from wells, many of them flowing wells, which draw their supply from the gravel and sand that constitute the plain.

The first eastern immigrants to settle in the San Bernardino Valley were a party of Mormons headed by Capt. Hunt, who came through Cajon Pass in 1851. Before this, however, there had been mission settlements in the area. One was established in 1810 near Bunker Hill, but it was destroyed by the Indians. Later a larger one was begun at old San Bernardino, on the south side of Santa Ana River. The padres in charge dug ditches, beginning between 1820 and 1830 with one from Mill Creek, which is the oldest ditch in the valley. In 1837 the mission lands were taken by the Mexican Government and given to Mexican landholders. It was from one of these landholders that the Mormons under Capt. Hunt purchased in 1851 the cultivated areas for $7,500.

At first the old ditches sufficed for the needs of the settlers, but as population increased other small ditches were dug. It was not until 1870 that the Riverside colony, made up mainly of settlers from New England, began the first large canal, but in the next 20 years many irrigation projects were developed. These utilized the greater part of the running water and considerable of the underground water. Most of the water was used for irrigating oranges and other citrus fruits. In 1904 an area of about 54,000 acres in the vicinity of San Bernardino, Redlands, and Riverside was under irrigation by water derived mainly from the San Bernardino Mountains, either from surface streams or from the underflow in the gravels at their foot.

It was soon found that the best conditions for citrus growth were to be had on the benches, where there was less liability to the low temperatures which sometimes kill the trees in the valley bottoms. The first orange trees were some seedlings grown in old San Bernardino, but it was not until the Riverside colony of 1870 was established that marketing of oranges began. The Bahia navel orange was first introduced at Riverside.[1] The principal factor in the orange business was the building of the railways which could give outlet to eastern markets; after this outlet was provided the production increased rapidly to its present great proportions. As the demand for water increased the methods of irrigation were improved, first by avoiding waste and then by careful application, so that in ordinary practice the volume used has diminished from 1 miner's inch[1] for 3 acres to about half as much. In the region about San Bernardino it is possible to obtain artesian water which flows under moderate pressure from the wells. The drain on this source of supply has somewhat reduced the volume and head of the water, so that the area in which flows are obtainable is now less than it was originally, though greater than it was after the dry period before 1900.

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[1] The original cuttings, from Bahia, Brazil, were sent to Florida from Washington, but some one, whose identity is not now known, took two of these cuttings to California. One of these two and all the cuttings in Florida died, so that the enormous business in navel oranges has grown from the slender beginning of a single cutting. The tree that lived may still be seen at Riverside.

Much of the water is used in the orange groves, but fruits of deciduous-leaved trees, small fruits, and vegetables are grown, and there are many acres of alfalfa. Grapes and barley require less water and need irrigation only in dry seasons, and these and beans are generally regarded as "dry" crops. Sugar beets are a very important crop, the great refinery near San Bernardino using 40,000 tons a year.

On leaving San Bernardino the train turns from a southerly to a due west course and begins its journey through the foothill valleys along the south side of the San Gabriel Range, first running across the plain which slopes gently southward to Santa Ana River from the foot of the San Gabriel Mountains.[2]

From the rear platform of the train the traveler, on leaving San Bernardino, can view the great mountain amphitheater, with its numerous ranges and peaks, which lies north of the east end of the San Bernardino Valley. Especially fine views may be had of San Gorgonio (altitude 11,485 feet), the highest peak in southern California; San Jacinto (altitude 10,805 feet), standing like a watch tower at the north end of the great range which extends southward for hundreds of miles to the end of Lower California; and San Antonio (sometimes called Mount Baldy; altitude 10,080 feet). San Antonio Peak is the highest summit of the San Gabriel Range, but not the highest mountain in southern California, as many suppose. All three of these peaks may be embraced in a single view. San Gorgonio Pass, through which runs the Southern Pacific Co.'s Sunset

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[1] A miner's inch (in California) is the amount of water which flows continuously through an orifice 1 inch square under a head of 4 inches. It equals 9 gallons a minute, $\frac{1}{50}$ second-foot, or 1 foot deep over 14,478 acres in a year. Citrus lands require about 1 miner's inch continuous flow for every 5 acres.

[2] The San Gabriel Mountains, like the San Bernardino Mountains, consist of granitic rocks of several kinds and a variety of other crystalline rocks, mainly schists, which were originally shales and sandstones, but have been altered by intrusions. It is believed that the range was uplifted in greater part in late Tertiary time. Apparently the uplift consisted of the rise of a huge block of the earth's crust along fault lines mostly trending N. 60° W. The main block was traversed by minor faults which have made the structure very complex.

Route to Yuma, Ariz., and beyond, may be seen in the distance, to the southeast.

From points west of San Bernardino, Colton, 3 miles to the south, is visible. Colton has large cement works with a capacity of 3,000 barrels a day, using the marble which constitutes Slover Mountain. Peaks of granite rise at intervals to the southwest. Riverside, 10 miles to the south, is faintly visible. It is one of the greatest orange-shipping centers in the world, receiving $4,000,000 yearly for its output. Riverside is famous for its beauty, the county courthouse and the high school being examples of notable architectural achievement. Near Riverside there is a large cement plant, one of the largest in California.

Rialto.
Elevation 1,199 feet.
Population 1,538.*
Kansas City 1,753 miles.

Rialto, nearly 4 miles west of San Bernardino, is in the midst of a thriving irrigation district which ships over 1,200 carloads of citrus fruit annually; her crop for 1914 brought $900,000. From this village a fine view is afforded of the east end of the San Gabriel Mountains,[1] to the northwest. To the southwest, at a distance of 4 to 6 miles, is a small range known as the Jurupa Mountains, rising about 1,000 feet above the plains. They consist of quartzites, schists, and limestones, or metamorphosed sedimentary rocks, penetrated by diorite and other igneous rocks. They are in sight to and beyond Fontana. Some of the plain in this region is not under cultivation on account of lack of water.

Etiwanda.
Elevation 1,121 feet.
Kansas City 1,762 miles.

The village of Etiwanda is about 2½ miles north of the railway station, or halfway across the plain reaching to the foot of the mountains. There are in this vicinity some large vineyards and also a considerable acreage of fruits of various kinds, notably of lemons, for which Etiwanda is famous.

Cucamonga.
Elevation 1,113 feet.
Population 2,340.*
Kansas City 1,766 miles.

Cucamonga is almost in the middle of the wide valley or plain that slopes southward from the foot of the San Gabriel Mountains to Santa Ana River. This region is extensively cultivated, in part without irrigation. It specializes in raisin and table grapes and in wines, of which it produces large quantities. The largest single vineyard in the world is located here. Cucamonga also has about 2,000 acres of oranges and lemons and 2,000 acres of peaches. From the railway fine views may be had of the San Gabriel Mountains. One peak, Cucamonga, which has an altitude of 8,911 feet, is conspicuous due north of the station, and other high ones are in view farther back in the range.

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[1] The San Gabriel Range, one of the most conspicuous and beautiful ranges of southern California, forms the watershed for the irrigation of a large part of the foothill valleys. Its individual peaks are more numerous than those of the San Bernardino plateau, and in its entirety it is a long uplifted fault block bordered on the north and south by downthrown areas.

Deep canyons lead out of the mountains at short intervals, and most of these contain living streams, whose water, if not diverted by irrigation ditches, sinks immediately at the mouths of the canyons and passes as a general underflow into the gravel and sand of the slope beyond. In times of freshet the streams flow greater or less distances across the slope, carrying much sediment, which is dropped as the water spreads out on the plain. Occasional great floods cross the plains, but much of the large volume of water they carry at such times is absorbed by the porous gravels of the stream beds. The courses of these ephemeral streams are marked by dry washes, usually shallow sandy channels, many of them splitting up irregularly and some of the branches rejoining.

One effective method of conserving water in this region, where water is so valuable, is to divert the flood waters near the canyon mouth, causing them to spread out widely over the coarse deposits, into which they sink, thus adding to the volume of underflow tapped by the many wells.

At Upland station the railway passes 2 miles north of Ontario, a city on the Southern Pacific Railroad, surrounded by wide areas of orange groves and other products of irrigation. Four miles to the northwest is the mouth of San Antonio Canyon, one of the large canyons in the San Gabriel Mountains, which furnishes considerable water for irrigation. On the plain its bed spreads into half a dozen irregular washes, which are crossed by the train between Upland and Claremont. From the gravel and sand under this plain a large amount of water is pumped for irrigation. Water is saved by lining the canals with concrete and by distributing it in underground pipes, methods which prevent loss by leakage and by evaporation.

Upland.

Elevation 1,210 feet.
Population 2,384.
Kansas City 1,769 miles.

West of Claremont a spur of the San Gabriel Mountains on the north extends nearer to the railway, and the San Jose Hills,[1] a northern extension of the Santa Ana Mountains, approach from the south. Owing to these conditions the valley narrows to about 3 miles at Lordsburg. In order to pass the San Jose Hills the railway has been deflected to the northwest, a course that soon takes it near the foot of the San Gabriel Mountains, which are closely skirted from San Dimas to Pasadena. Lordsburg was originally a Dunkard settlement. It has numerous orange and lemon groves.

Lordsburg.

Elevation 1,039 feet.
Population 954.
Kansas City 1,776 miles.

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[1] The San Jose Hills consist mainly of a thick series of sandstones and shales of the lower part of the Fernando formation (Miocene), flexed in broad basins and arches. At their east end, south of Lordsburg, is an area of granitic rock.

From Lordsburg to Azusa the irrigated areas are almost continuous, and many extensive and beautiful orchards may be observed at frequent intervals. Water for irrigation is brought from San Gabriel Canyon, and large amounts are pumped from wells and distributed by numerous canals.

San Dimas.
Elevation 939 feet.
Kansas City 1,778 miles.

North of San Dimas (dee′mas) a mass of sandstones and shales with interbedded volcanic rocks is exposed at the foot of the mountains. The beds dip north toward the older rocks of the range, from which they are separated by a fault.

Near milepost 112, halfway between San Dimas and Glendora, the train crosses the dry wash of San Dimas Creek, which heads in a large canyon a few miles to the northeast. It is a good example of a wash formed by a powerful intermittent stream. Beyond San Dimas Wash the train skirts the east end and north side of an isolated hill consisting of Tertiary sandstone and shale and enters the village of Glendora.

Glendora.
Elevation 765 feet.
Kansas City 1,782 miles.

From Glendora to Azusa and in a wide area on the south are numerous orange groves and other orchards, most of them irrigated by canals from San Gabriel River, which comes out of a large canyon a few miles to the northwest. Pumping plants also add to the supply, for there is considerable water in the sand and gravel under the plain.

Azusa.
Elevation 614 feet.
Population 1,477.
Kansas City 1,785 miles.

Near Azusa the railway is within a mile of the foot of the steep southern front of the San Gabriel Mountains, which has been followed all the way west from the mouth of Cajon Canyon and continues to Los Angeles. Two miles west of Azusa the train crosses San Gabriel Wash, the bed of San Gabriel River, the largest stream flowing from the San Gabriel Mountains. The canyon through which the San Gabriel emerges from the mountains is in sight about 3 miles northeast of the trestle over the wash. During the rainy season San Gabriel River is a stream of considerable size, furnishing water for irrigating many citrus groves and other orchards and fields on the slope south of the mountains. During the dry periods it dwindles to a mere brooklet, even within the canyon. Under ordinary conditions the wash below the canyon is dry between the canyon mouth and a point 10 or 12 miles to the southwest, where the water breaks out in springs. Some of it also comes out in Lexington Wash, near El Monte. In times of freshet a large volume of water passes down San Gabriel Wash, as may be inferred from the large bowlders in its bed. These bowlders are crushed for road material and other uses. The crusher and deep pit are on the south side of the track and a large amount of material is available in masses convenient to elevate directly into the crusher.

Monrovia.
Elevation 432 feet.
Population 3,576.
Kansas City 1,790 miles.

Monrovia station is in the southern part of Monrovia, an old settlement lying against the foot of the mountains. West of Monrovia the railway swerves to the northwest for 2 miles and then goes west through the small towns of Arcadia, Santa Anita, and Lamanda Park into Pasadena. There is a gradual ascent in this part of the line for about 350 feet.

About 3½ miles south of Lamanda Park is the San Gabriel Mission, one of the 21 missions established by the Franciscans between San Diego and San Francisco. It is in an excellent state of preservation and is typical of the architecture introduced by the friars. (See Pl. XLI, *B*, p. 168.)

Pasadena.
Elevation 850 feet.
Population 30,291.
Kansas City 1,800 miles.

Pasadena is situated in a "rincón" or corner between the San Gabriel Range, which bears off to the northwest, and the San Rafael Hills,[1] which rise as rocky ridges nearly 1,000 feet high west of northwest of the city. It is undoubtedly these features which give Pasadena certain climatic conditions (protection from cold winds and slightly greater rainfall than that in some of the regions farther east and south) that make it particularly attractive as a winter resort. The name Pasadena is an Indian word meaning crown of the valley. Here the railway turns south to reach South Pasadena and thence goes southwest for several miles, over a low pass through the hills separating the Pasadena Plain from the Los Angeles Valley. The portion of these hills near the railway consists of soft buff sandstones and shales,[2] gently flexed in broad basins and arches.

As the train leaves South Pasadena it enters the valley of the Arroyo Seco, which it follows to Los Angeles River, in the northern part of the city of Los Angeles. The city is built on the low river terraces, on the inner edge of the coastal plain which extends west and south to the Pacific Ocean, and on the hills of folded and faulted Tertiary sandstone and shale which rise above the plain and the terraces. Los Angeles River itself, like other streams of the arid Southwest, is a river in name only except during the heavy rains of winter, when at times it becomes a deep torrent which often does considerable damage.

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[1] The San Rafael Hills are part of a low mountain block of granites and schists believed to have been unlifted between two faults trending west-northwest, parallel to a great fault here extending along the south foot of the San Gabriel Mountains. A part of the southern slope of these hills between Pasadena and Glendale is made up of heavy sandstone of Tertiary age. Eagle Rock, a well-known topographic feature here, is a picturesque outcrop of this sandstone.

[2] The rocks of the Monterey group are of marine origin and indicate that in Miocene time (see p. ii) the Coastal Plain region was submerged by the sea at intervals and the sands and muds were deposited in wide estuaries and along beaches. There was a long epoch of general subsidence, and a great thickness of these materials thus accumulated. They have since been uplifted, bent, and faulted, and later terraces and plains were developed across the surface.

Los Angeles.
Elevation 293 feet.
Population 319,198.
Kansas City 1,809 miles.

Los Angeles (Spanish pronunciation loce ahn′hay-lace) is the largest city of the Southwest, in area, population, and business. It was here, in 1846, that Gen. Frémont first raised the American flag. The settlement, however, was founded in 1781, by a garrison of soldiers from the mission of San Gabriel, 65 years prior to Frémont's visit. In 1831 it had a population of 770, and as late as 1880 it was an easy-going semi-Mexican town of 12,000 inhabitants centered about the old plaza with the mission church of Nuestra Señora la Reina de los Ángeles (Our Lady Queen of the Angels), from which the city takes its name. With the coming of the Santa Fe Railway in November, 1885, homeseekers began to arrive, and a great increase in property values and the extent of the city followed. According to the United States census, Los Angeles made a greater percentage of increase in population from 1880 to 1900 than any other town in the United States, and the figures have shown remarkably rapid increase since 1900. A city census taken in June, 1915, indicates a population of 528,000. Two important factors in its growth have been the development of electric power from mountain streams as much as 240 miles away and the availability of cheap petroleum fuel.

In the northern part of the city is a belt of oil-producing territory 5½ miles long, covering an area of 2 square miles. Here hundreds of derricks have been erected in close proximity to dwellings.[1]

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[1] The following notes are based on a concise account of the geology and technology of the California oil fields by Ralph Arnold and V. R. Garfias:

The production of petroleum in California is the most important mineral industry in the State, the annual value of the oil output equaling that of all the metals. Since 1903, with the exception of 1907 and 1908, California has annually produced more petroleum than any other State in the Union, and in 1914 the production was over 100,000,000 barrels.

The principal oil fields adjacent to Los Angeles are those of the Los Angeles district and the Puente Hills district. The Los Angeles district includes the City field, lying in the city of Los Angeles, and the Salt Lake field immediately west of the city limits, about 4½ miles from its business center.

The City field was discovered in 1892, when a 155-foot shaft was sunk near a small deposit of brea on Colton Street. The first successful well was drilled later in that year on Second Street, and by the end of 1895 there were more than 300 wells. This field forms a narrow belt about 5½ miles long running through the northern part of the city; the total area is about 2 square miles. The wells are from 500 to 1,200 feet in depth, and the gravity of the oil ranges from 12° to 19° Baumé. The limits of the field are well defined. The wells have always been small producers, necessitating pumping, and owing to the great number of wells drilled within a small area the field has been drained at a rapid rate and water allowed to enter the oil sands in many areas.

The first well in the Salt Lake field was drilled in 1901 by the Salt Lake Oil Co., One notable feature in the recent development of the city has been the construction of an aqueduct 226 miles long to bring water from Owens Valley. The capacity of this line is 250,000,000 gallons a day, sufficient to supply a population of more than a million. It cost about $25,000,000. At present (July 1, 1915) the surplus water is used for the irrigation of about 8,000 acres a few miles north of the city. Los Angeles County claims to be the richest county in the United States in value of farm property and agricultural products. The estimated value of all property in the county January 1, 1915, was given at $1,500,000,000. General building operations in the city in 1913 represented an expenditure of more than $31,000,000 for materials and labor. Los Angeles has many parks, including one containing 3,000 acres, the largest municipal park in the world. There are 726 miles of improved streets, and the adjoining region has many miles of fine roads. About 25 miles south of the main body of the city is San Pedro, on the ocean, a port from which there is an extensive coast and trans-Pacific trade.

The Museum of History, Science, and Art is one of the most interesting places in the city. It has fine collections in many branches,

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and since 1902 this field has been the chief producer in the Los Angeles district. The wells are deeper than in the City field, ranging between 1,200 and 3,000 feet, and the average gravity of the oil is between 16° and 18° Baumé. Considerable gas under strong pressure accompanies the oil, which causes the wells to gush during the early part of their life.

The oil in the Los Angeles district is derived largely from the upper 500 feet of the Monterey group and the basal beds of the Fernando formation. During 1914 the district produced about 2,500,000 barrels of oil, and between 1894 and the end of 1914 it produced over 40,000,000 barrels. At present there are about 700 producing wells in the district. The average production in the City field is about 2½ barrels a day for each well and in the Salt Lake field about 23 barrels.

The oils of the City field are uniform in quality, although they vary considerably in gravity. They contain considerable sulphur, and owing to the entire absence of light products are of little value for refining, being used almost entirely for fuel. The oils produced in the Salt Lake field show a marked similarity in general properties, being characterized by a high percentage of sulphur. The heavy oils are highly viscous, and the yield of asphalt is considerable.

The Puente Hills district, from 12 to 34 miles southeast of Los Angeles, was the second oil district discovered in California. The first producing well in it was completed in 1880. Until 1893 the Puente Hills and Santa Clara River Valley districts yielded practically all the oil produced in California. The average depth of the wells in the Puente Hills district is somewhat more than 1,300 feet and the average life of the wells about 16 years. The gravity of the oil varies between 21° and 32° Baumé.

The lighter grades of oil are believed to come from the Monterey groups, the heavier grades are derived largely from the coarser sediments of the Fernando.

On December 31, 1912, there were 470 producing wells in the Puente Hills district, and the output for the year was nearly 7,000,000 barrels. The total production of the field from 1889 to 1912, inclusive, was nearly 41,000,000 barrels. The oil produced varies greatly in composition, the greater portion being of light grade and utilized by refineries near Los Angeles.

exhibited in an attractive and instructive manner. The museum authorities control the wonderful bone deposits in the asphalt springs of Rancho La Brea, about 8 miles directly west of the city. These springs have been for centuries the most effective natural animal trap known, and the asphalt has preserved the bones of the thousands of extinct as well as modern animals caught in its deceptive and sticky pools. The skeletons of elephants, camels, sloths, saber-toothed tigers, bears, and myriads of smaller animals, including many birds, are being gradually dug out and set up in the museum. Among the bones has recently been found the skull of a human being who lived probably not less than 10,000 years ago, contemporaneously with many animals now extinct.

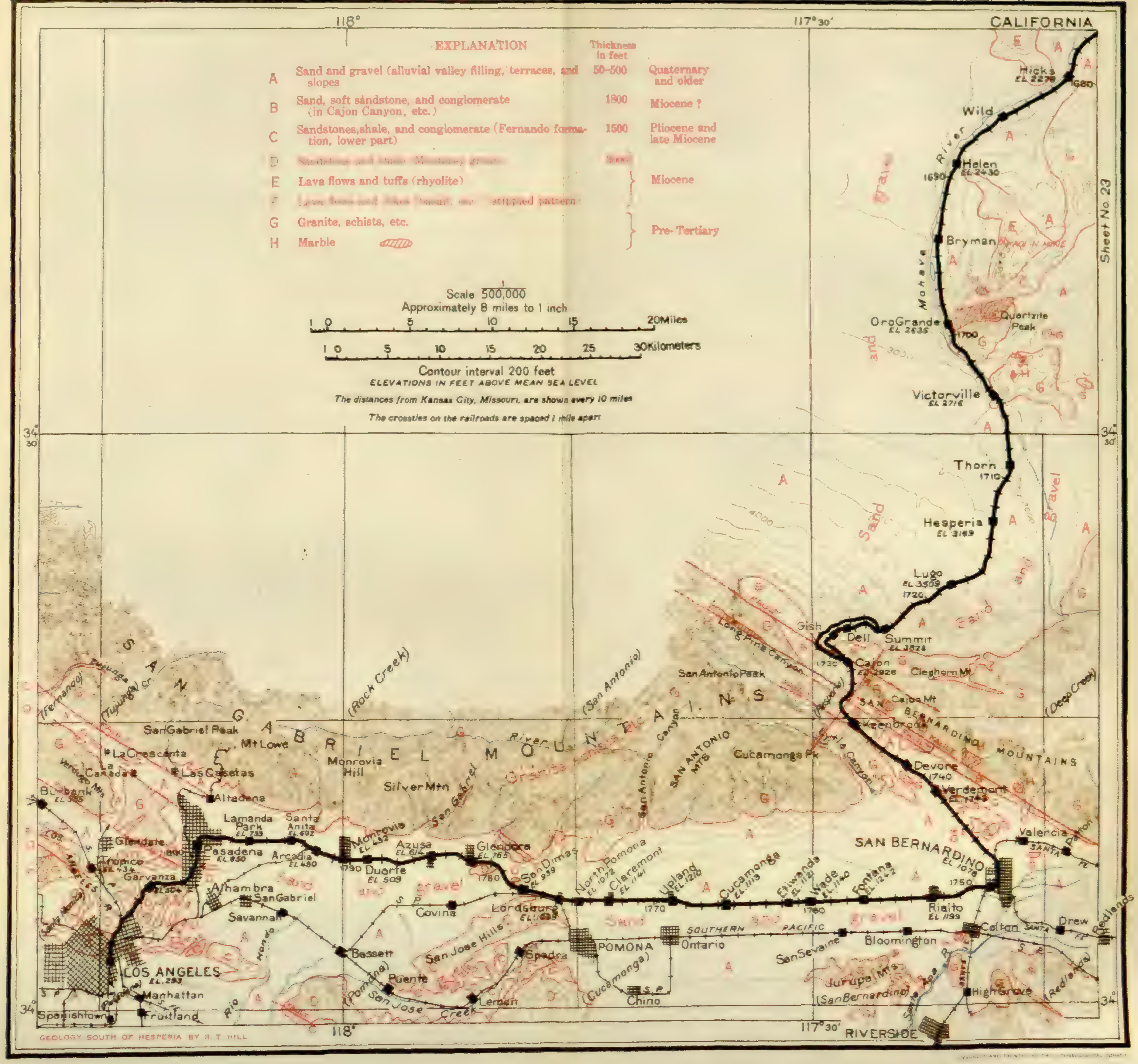
With the permission of the Museum of History, Science, and Art the Rancho La Brea may be visited. On the way thither the traveler passes over a portion of the great alluvial plain of Los Angeles, which is underlain, at least in part, by three Quaternary formations, the oldest of which is a marine deposit laid down horizontally on the beveled edges of a very thick series of tilted Pliocene beds. This marine Quaternary deposit has a thickness of 100 feet in the north-western portion of the city, but thins to an edge near the ancient sea cliff beyond. Los Angeles River excavated a valley about a mile wide and 100 feet deep in the marine deposit and filled the trench with river deposits, the second Quaternary formation. This in turn is covered by the alluvium of the present plain.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
SANTA FE ROUTE
From Kansas City, Missouri, to Los Angeles, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Atcheson, Topeka and Santa Fe Railway and from additional information collected with the assistance of this company

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist R. B. Marshall, Chief Geographer
1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.



EXPLANATION

		Thickness in feet	
A	Sand and gravel (alluvial valley filling, terraces, and slopes	50–500	Quaternary and older
B	Sand, soft sandstone, and conglomerate (in Cajon Canyon, etc.)	1800	Miocene ?
C	Sandstones, shale, and conglomerate (Fernando formation, lower part)	1500	Pliocene and late Miocene
D	Sandstone and shale (Monterey group)	[illegible]	
E	Lava flows and tuffs (rhyolite)		Miocene
F	Lava flows and dikes (basalt, etc.) (stippled pattern)		
G	Granite, schists, etc.		Pre-Tertiary
H	Marble ▨		

Scale $\frac{1}{500,000}$
Approximately 8 miles to 1 inch
1 0 5 10 15 20 Miles
1 0 5 10 15 20 25 30 Kilometers
Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from Kansas City, Missouri, are shown every 10 miles
The crossties on the railroads are spaced 1 mile apart

RECENT PUBLICATIONS DESCRIBING GEOLOGY ALONG THE SANTA FE RAILWAY.

EASTERN AND CENTRAL KANSAS.

Adams, G. I., Girty, G. H., and White, David, Stratigraphy and paleontology of the Upper Carboniferous rocks of the Kansas section: U. S. Geol. Survey Bull. 211, 1903.

Beede, J. W., Stratigraphy of Shawnee County: Kansas Acad. Sci. Trans., vol. 15, pp. 27–31, 1896.

——— McPherson Equus beds: Idem, vol. 15, pp. 104–110, 1898.

——— Formations of the Marion stage of the Kansas Permian: Idem, vol. 21, pt. 2, pp. 247–256, 1909. See also Prosser and Beede.

Beede, J. W., and Sellards, E. H., Notes on Permian formations of Kansas: Am. Geologist, vol. 36, pp. 83–111, 1905.

Gould, C. N., The Dakota-Cretaceous of Kansas and Nebraska: Kansas Acad. Sci. Trans., vol. 17, pp. 1–64, 1901.

Haworth, Erasmus, Report on field work in Kansas: Kansas Univ. Quart., vol. 2, pp. 99–142, pls. 4, 5, 1894.

——— McPherson Equus beds: Kansas Geol. Survey Rept., vol. 2, pp. 287–296, 1897.

Kansas Academy of Sciences, Transactions, vols. 1 to 22, 1868–1909.

Kansas University Geological Survey, Reports, vols. 1 to 9, 1896–1908.

Prosser, C. S., Revised classification of upper Paleozoic formations of Kansas: Jour. Geology, vol. 10, pp. 703-737, 1902.

——— Notes on the Permian formations of Kansas: Am. Geologist, vol. 36, pp. 142–161, 1905.

Prosser, C. S., and Beede, J. W., U. S. Geol. Survey Geol. Atlas, Cottonwood Falls folio (No. 109), 1904.

Smith, A. J., Geology of Lyon County, Emporia, 1902.

Smyth, B. B., Well boring at Topeka: Kansas Acad. Sci. Trans., vol. 14, p. 207.

Todd, J. E., Drainage of Kansas ice sheet: Kansas Acad. Sci. Trans., vol. 22, pp. 107-112, 1909.

——— History of Wakarusa Creek: Idem, vol. 24, pp. 211–218, 1910.

WESTERN KANSAS.

Darton, N. H., Geology and underground water resources of the central Great Plains: U. S. Geol. Survey Prof. Paper 32, 433 pp., 72 pls., 1905.

Johnson, W. D., The high plains and their utilization: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 4, pp. 601–741, pls. 113–156, 1900; Twenty-second Ann. Rept., pt. 4, pp. 631–669, pls. 51–65, 1901.

SOUTHEASTERN COLORADO.

Darton, N. H., Geology and underground water resources of the Arkansas Valley in eastern Colorado: U. S. Geol. Survey Prof. Paper 52, 90 pp., 28 pls., 1906.

Hills, R. C., U. S. Geol. Survey Geol. Atlas, Spanish Peaks and El Moro folios (Nos. 71 and 58).

Richardson, G. B., The Trinidad coal field, Colorado: U. S. Geol. Survey Bull. 381, pp. 379–446, 1910.

Stose, G. W., U. S. Geol. Survey Geol. Atlas, Apishapa folio (No. 186), 1912.

NORTHEASTERN NEW MEXICO.

Bryan, Kirk, Geology of vicinity of Albuquerque: New Mexico Univ. Bull. 51; Geol. ser., vol. 3, No. 1, June, 1909.

Lee, W. T., Stratigraphy of the coal fields of northern-central New Mexico: Geol. Soc. America Bull., vol. 23, pp. 571–586, 1912.

——— The Cerrillos coal field, Santa Fe County, N. Mex.: U. S. Geol. Survey Bull. 531, pp. 285–312, maps, Washington, 1913.

Lee, W. T., and **Girty, G. H.**, The Manzano group of the Rio Grande valley, New Mexico: U. S. Geol. Survey Bull. 389, Washington, 1909.

Johnson, D. W., Geology of Los Cerrillos Hills: Colorado Univ. School of Mines Quart., vol. 24, pp. 173–246, 303–350, 456–500; vol. 25, pp. 69–98, 1903.

Sterrett, D. B., Gems and precious stones (Turquoise of Los Cerrillos): U. S. Geol. Survey Mineral Resources, 1911, pt. 2, pp. 1065–1071, 1912.

WESTERN NEW MEXICO AND ARIZONA.

Darton, N. H., A reconnaissance of parts of northwestern New Mexico and northern Arizona: U. S. Geol. Survey Bull. 435, 88 pp., 17 pls., 1910.

Dutton, C. E., Mount Taylor and the Zuni Plateau: U. S. Geol. Survey Sixth Ann. Rept., pp. 105–198, pls. 11–22, 1886.

Gregory, H. E., The Shinarump conglomerate: Am. Jour. Sci., 4th ser., vol. 35, pp. 424–438, 1913.

Johnson, D. W., Volcanic necks of the Mount Taylor region: Geol. Soc. America Bull., vol. 18, pp. 303–324, 1907.

Knowlton, F. H., Fossil forests of Arizona: Am. Forestry, vol. 19, pp. 207–218, April, 1913.

Merrill, G. P., The petrified forest, 23 pp., 7 pls., Adamana, Ariz.

Robinson, H. H., The San Franciscan volcanic field, Arizona: U. S. Geol. Survey Prof. Paper 76, 213 pp., 14 pls., 1913.

Shimer, H. W., and **Blodgett, M. E.**, Stratigraphy of the Mount Taylor region, New Mexico: Am. Jour. Sci., 4th ser., vol. 25, pp. 53–67, 1908.

GRAND CANYON.

Darton, N. H., A reconnaissance of parts of northwestern New Mexico and northern Arizona: U. S. Geol. Survey Bull. 435, 88 pp., 17 pls., 1910.

Davis, W. M., Excursion to the Grand Canyon: Harvard Coll. Mus. Comp. Zool. Bull.; Geol. ser., vol. 5, No. 4, pp. 107–201, 1901.

Noble, L. F., The Shinumo quadrangle, Grand Canyon district, Arizona: U. S. Geol. Survey Bull. 549, 100 pp., 18 pls., 1914.

Walcott, C. D., Pre-Cambrian igneous rocks of the Unkar terrane, Grand Canyon of the Colorado, Arizona: U. S. Geol. Survey Fourteenth Ann. Rept., pt. 2, pp. 497–524, pls. 60–65, 1894.

WESTERN ARIZONA.

Lee, W. T., Geologic reconnaissance of a part of western Arizona: U. S. Geol. Survey Bull. 352, 96 pp., 11 pls., 1908.

Schrader, F. C., Mineral deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Ariz.: U. S. Geol. Survey Bull. 397, 226 pp., 16 pls., 1909.

SOUTHEASTERN CALIFORNIA.

Arnold, Ralph, and **Strong, A. M.**, Some crystalline rocks of the San Gabriel Mountains, California: Geol. Soc. America Bull., vol. 16, pp. 183–204, 1905.

Baker, C. L., Notes on the later Cenozoic history of the Mojave Desert region in southeastern California: California Univ. Dept. Geology Bull., vol. 6, pp. 333–383, pls. 34–43, 1911.

CAMPBELL, M. R., Reconnaissance of the borax deposits of Death Valley and Mohave Desert, Cal.: U. S. Geol. Survey Bull. 200, 23 pp., 1902.

DARTON, N. H., Discovery of Cambrian rocks in southeastern California: Jour. Geology, vol. 15, pp. 470–473, 1907.

ELDRIDGE, G. H., and ARNOLD, RALPH: The Santa Clara Valley, Puente Hills, and Los Angeles oil districts, southern California: U. S. Geol. Survey Bull. 309, 266 pp., 41 pls., 1907.

HERSHEY, O. H., Some crystalline rocks of southern California: Am. Geologist, vol. 29, pp. 273–290, 1902.

——— The Quaternary of southern California: Univ. California Dept. Geology Bull., vol. 3, pp. 21–25, 1902.

KEYES, C. R., Borax deposits of the United States: Am. Inst. Min. Eng. Trans., vol. 34, pp. 867–903, 1909.

LINDGREN, WALDEMAR, The silver mines of Calico, Cal.: Am. Inst. Min. Eng. Trans., vol. 15, pp. 717–734, 1887.

MENDENHALL, W. C., Hydrology of San Bernardino Valley, Cal.: U. S. Geol. Survey Water-Supply Paper 142, 83 pp., 5 pls., 1905.

——— Two mountain ranges in southern California (San Bernardino and San Gabriel): Geol. Soc. America Bull., vol. 19, pp. 660–661, 1908.

——— Ground waters and irrigation enterprises in the foothill belt, southern California: U. S. Geol. Survey Water-Supply Paper 219, 180 pp., 9 pls., 1908.

PACK, R. W., Reconnaissance of the Barstow–Kramer region, Cal.: U. S. Geol. Survey Bull. 541, pp. 141–154, 1913.

STORMS, W. H., Mineral resources of San Bernardino County, Cal.: California State Min. Bur. Eleventh Ann. Rept., pp. 345–348, 1893.

YALE, C. G., and GALE, H. S., Borax: U. S. Geol. Survey Mineral Resources, 1912, pt. 2, pp. 839–846, 1913.

GLOSSARY OF GEOLOGIC TERMS.

Alluvial fan. The outspread sloping deposit of bowlders, gravel, and sand left by a stream where it passes from a gorge out upon a plain.

Andesite. A lava of widespread occurrence, usually of dark-gray color and intermediate in chemical composition between rhyolite and basalt.

Anticline. An arch of bedded or layered rock suggestive in form of an overturned canoe. (See fig. 16, p. 86; fig. 25, p. 117; Pl. XIX, *B*, p. 103.) See also Dome and Syncline.)

Badlands. A region nearly devoid of vegetation where erosion, instead of carving hills and valleys of the familiar type, has cut the land into an intricate maze of narrow ravines and sharp crests and pinnacles. Travel across such a region is almost impossible, hence the name. (See Pl. XXII, p. 110.)

Basalt. A common lava of dark color and of great fluidity when molten. Basalt is less siliceous than granite and rhyolite, and contains much more iron, calcium, and magnesium.

Bolson (pronounced bowl-sown′). A flat-floored desert valley that drains to a central evaporation pan or playa.

Bomb. See Volcanic bomb.

Breccia (pronounced bretch′ya). A mass of naturally cemented angular rock fragments.

Cross-bedding. Irregular bedding at an angle oblique to the general plane of stratification (see Sedimentary rocks), formed by the action of tides or currents varying in direction and force. (See Pl. XVII, p. 101; Pl. XXIX, p. 119.)

Crystalline rock. A rock composed of closely fitting mineral crystals that have formed in the rock substance, as contrasted with one made up of cemented grains of sand or other material or with a volcanic glass.

Diabase. A heavy, dark intrusive rock having the same composition as basalt but, on account of its slower cooling, a more crystalline texture. Its principal constituent minerals are feldspar, augite, and usually olivine. Olivine is easily changed by weathering, and in many diabases is no longer recognizable. Augite is a mineral containing iron and magnesium and is similar to hornblende.

Dike. A mass of igneous rock that has solidified in a wide fissure or crack in the earth's crust. (See fig. 8, p. 54; Pl. VII, p. 53.)

Diorite. An even-grained intrusive igneous rock consisting chiefly of the minerals feldspar, hornblende, and very commonly black mica. If the rock contains much quartz, it is called quartz diorite. Quartz diorite resembles granite and is connected with that rock by many intermediate varieties, including monzonite. The feldspar in diorite differs from that in granite in containing calcium and sodium instead of potassium. Hornblende is a green or black mineral containing iron, magnesium, calcium, and other constituents.

Dip. The slope of a rock layer expressed by the angle which the top or bottom of the layer makes with a horizontal plane. (See fig. 3, p. 14; fig. 13, p. 71; Pl. XVIII, p. 102; Pl. XX, *B*, p. 106.) (See also Strike.)

Dissected. Cut by erosion into hills and valleys. Applicable especially to plains or peneplains in process of erosion after an uplift.

Dome. As applied to rock layers or beds, a short anticline, suggestive of an inverted basin.

Drift. The rock fragments—soil, gravel, and silt—carried by a glacier. Drift includes the unassorted material known as till and deposits made by streams flowing from a glacier.

Erosion. The wearing away of materials at the earth's surface by the mechanical action of running water, waves, moving ice, or winds, which use rock fragments and grains as tools or abrasives. See Pl. XVII, p. 101; Pls. XXX–XXXIII, pp. 126–127.) Erosion is aided by weathering. (See Weathering.)

Fault. A fracture in the earth's crust accompanied by movement of the rock on one side of the break past that on the other. If the fracture is inclined and the rock on one side appears to have slid down the slope of the fracture the fault is termed a normal fault. If, on the other hand, the rock on one side appears to have been shoved up the inclined plane of the break the fault is termed a reverse fault. (See fig. 14, p. 78; fig. 17, p. 92; fig. 28, p. 127.)

Fault block. A part of the earth's crust bounded wholly or in part by faults.

Fault scarp. The cliff formed by a fault. Most fault scarps have been modified by erosion since the faulting.

Fauna. The animals that inhabited the world or a certain region at a certain time.

Fissure. A crack, break, or fracture in the earth's crust or in a mass of rock.

Flood plain. The nearly level land that borders a stream and is subject to occasional overflow. Flood plains are built up by sediment left by such overflows.

Flora. The assemblage of plants growing at a given time or in a given place.

Fold. A bend in rock layers or beds. Anticlines and synclines are the common types of folds.

Formation. A rock layer, or a series of continuously deposited layers grouped together, regarded by the geologist as a unit for purposes of description and mapping. A formation is usually named from some place where it is exposed in its typical character. For example, Denver formation, Niobrara limestone.

Fossil. The whole or any part of an animal or plant that has been preserved in the rocks or the impression left by a plant or animal. This preservation is invariably accompanied by change in substance, and from some impressions the original substance has all been removed. (See Pl. XXI, p. 107.)

Gneiss (pronounced nice). A rock resembling granite, but with its mineral constituents so arranged as to give it a banded appearance. Most gneisses are metamorphic rocks derived from granite or other igneous rocks.

Granite. A crystalline igneous rock that has solidified slowly deep within the earth. It consists chiefly of the minerals quartz, feldspar, and one or both of the common kinds of mica, namely, black mica, or biotite, and white mica, or muscovite. The feldspar is the kind known as orthoclase, and may be distinguished from quartz by its pale-reddish tint and its property of breaking with flat shining surfaces (cleavage), for quartz breaks irregularly. The micas are easily recognized by their cleavage into thin, flexible flakes and their brilliant luster.

Horizon. In geology any distinctive plane traceable from place to place in different exposures of strata and marking the same period of geologic time. A particular horizon may be characterized by distinctive fossils.

Igneous rocks. Rocks formed by the cooling and solidification of a hot liquid material, known as magma, that has originated at unknown depths within the earth. Those that have solidified beneath the surface are known as intrusive rocks, or if the cooling has taken place slowly at great depth, as plutonic intrusive or plutonic rocks. Those that have flowed out over the surface are known as effusive rocks, extrusive rocks, or lavas. The term volcanic rocks includes not only lavas, but bombs, pumice, tuff, volcanic ash, and other fragmental materials or ejecta thrown out from volcanoes.

Lithologic. Pertaining to lithology, or the study of rocks. (See also Petrology.) Pertaining to rock character.

Lode. An ore-bearing vein (see Vein); especially a broad or complex vein.

Loess (pronounced lurse with the r obscure). A fine homogeneous silt or loam showing usually no division into layers and forming thick and extensive deposits in the Mississippi Valley and in China. It is generally regarded as in part at least a deposit of wind-blown dust.

Meander. To flow in serpentine curves. A loop in a stream. The term comes from the Greek name of a river in Asia Minor, which has a sinuous course. Most streams in flowing across plains develop meanders.

Metamorphism. Any change in rocks effected in the earth by heat, pressure, solutions, or gases. A common cause of the metamorphism of rocks is the intrusion into them of igneous rocks. Rocks that have been so changed are termed metamorphic. Marble, for example, is metamorphosed limestone.

Monzonite. An even-grained intrusive igneous rock intermediate in character between diorite and granite. It resembles granite.

Moraine. A mass of drift deposited by a glacier at its end or along its sides.

Oil pool. An accumulation or body of oil in sedimentary rock that yields petroleum on drilling. The oil occurs in the pores of the rock and is not a pool or pond in the ordinary sense of these words.

Outcrop. That part of a rock that appears at the surface. The appearance of a rock at the surface or its projection above the soil. (See Pl. IX, p. 57.)

Paleontology. The study of the world's ancient life, either plant or animal, by means of fossils.

Peneplain. A region reduced almost to a plain by the long-continued normal erosion of a land surface. It should be distinguished from a plain produced by the attack of waves along a coast or the built-up flood plain of a river.

Petrography. The description of rocks, especially of igneous and metamorphic rocks studied with the aid of the microscope.

Petrology. The study of rocks, especially of igneous and metamorphic rocks.

Placer deposit. A mass of gravel, sand, or similar material resulting from the crumbling and erosion of solid rocks and containing particles or nuggets of gold, platinum, tin, or other valuable minerals, which have been derived from rocks or veins.

Playa (pronounced plah′ya). The shallow central basin of a desert plain, in which water gathers after a rain and is evaporated.

Porphyry. Any igneous rock in which certain crystal constituents are distinctly visible in contrast with the finer-grained substance of the rock.

Quartzite. A rock composed of sand grains cemented by silica into an extremely hard mass.

Rhyolite. A lava, usually of light color, corresponding in chemical composition to granite. The same molten liquid that at great depth within the earth solidifies as granite would, if it flowed out on the surface, cool more quickly and crystallize less completely as rhyolite.

Schist. A rock that by subjection to heat and pressure within the earth has undergone a change in the character of the particles or minerals that compose it and has these minerals arranged in such a way that the rock splits more easily in certain directions than in others. A schist has a crystalline grain roughly comparable with the grain of a piece of wood.

Sedimentary rocks. Rocks formed by the accumulation of sediment in water (aqueous deposits) or from air (eolian deposits). The sediment may consist of rock fragments or particles of various sizes (conglomerate, sandstone, shale); of the remains or products of animals or plants (certain limestones and coal); of the product of chemical action or of evaporation (salt, gypsum, etc.); or of mixtures of these materials. Some sedimentary deposits (tuffs) are composed of fragments blown from volcanoes and deposited on land or in water. A characteristic feature of sedimentary deposits is a layered structure known as bedding or stratification. Each layer is a bed or stratum. Sedimentary beds as deposited lie flat or nearly flat. (See Pl. VI, p. 52; Pl. XXVI, p. 114; Pl. XXXII, p. 126.)

Shale. A rock consisting of hardened thin layers of fine mud.

Slate. A rock that by subjection to pressure within the earth has acquired the property of splitting smoothly into thin plates. The cleavage is smoother and more regular than the splitting of schist along its grain.

Stratigraphy. The branch of geologic science that deals with the order and relations of the strata of the earth's crust.

Strike. The direction along which an inclined rock layer would meet the earth's surface if that surface were level. The outcrop (which see) of a bed on a plain is coincident with its strike.

Structure. In geology, the forms assumed by sedimentary beds and igneous rocks that have been moved from their original position by forces within the earth, or the forms taken by intrusive masses of igneous rock in connection with effects produced mechanically on neighboring rocks by the intrusion. Folds (anticlines and synclines) and faults are the principal mechanical effects considered under structure. Schistosity and cleavage are also structural features.

Syncline. An inverted arch of bedded or layered rock suggestive in form of a canoe. (See fig. 12, p. 68.)

Talus (pronounced tay'lus). The mass of loose rock fragments that accumulates at the base of a cliff or steep slope. (See Pl. XXXVI, p. 135.)

Terrace. A steplike bench on a hillside. Most terraces along rivers are remnants of valley bottoms formed when the stream flowed at higher levels. Other terraces have been formed by waves. Some terraces have been cut in solid rock, others have been built up of sand and gravel, and still others have been partly cut and partly built up.

Till. The deposit of mingled bowlders, rock fragments, and soil left behind by a melting glacier or deposited about its margin.

Tuff. A rock consisting of a layer or layers of lava particles blown from a volcano. A fine tuff is often called volcanic ash and a coarse tuff is called breccia.

Type locality. The place at which a formation is typically displayed and from which it is named; also the place at which a fossil or other geologic feature is displayed in typical form.

Unconformity. A break in the regular succession of sedimentary rocks, indicated by the fact that one bed rests on the eroded surface of one or more beds which may have a distinctly different dip from the bed above. An unconformity may indicate that the beds below it have at some time been raised above the sea and have been eroded. In some places beds thousands of feet thick have been washed away before the land again became submerged and the first bed above the surface of unconformity was deposited. If beds of rock may be regarded as leaves in the volume of geologic history, an unconformity marks a gap in the record. (See fig. 28, p. 127; fig. 30, p. 130.)

Vein. A mass of mineral material that has been deposited in or along a fissure in the rocks. A vein differs from a dike in that the vein material was introduced gradually by deposition from solution whereas a dike was intruded in a molten condition.

Volcanic bomb. A rounded mass of lava thrown out while in a hot and pasty condition from a volcano. A bomb, like a raindrop, is rounded in its passage through the air and may be covered with a cracked crust due to quick cooling.

Volcanic cone. A mountain or hill, usually of characteristic conical form, built up around a volcanic vent. The more nearly perfect cones are composed principally of lava fragments and volcanic ashes. (See fig. 38, p. 155; Pl. XIV, *B*, p. 100; Pl. XXVI, p. 115.)

Volcanic glass. Lava that has cooled and solidified before it has had time to crystallize.

Volcanic neck. A plug of lava that congealed in the pipe of a volcano. When the tuffs and lava flows that make up most of a volcanic cone have been washed away by erosion the neck may remain as an isolated hill. (See fig. 20, p. 97.)

Volcanic rocks. Igneous rocks erupted at or near the earth's surface, including lavas, tuffs, volcanic ashes, and like material.

Weathering. The group of processes, such as the chemical action of air and rain water and of plants and bacteria and the mechanical action of changes of temperature, whereby rocks on exposure to the weather change in character, decay, and finally crumble into soil. (See Pl. XXXVII, p. 140.)

ILLUSTRATIONS.

ROUTE MAP.

For the convenience of the traveler the sheets of the route map are so folded and placed that he can unfold them one by one and keep each one in view while he is reading the text relating to it. A reference in parentheses is given in the text at each point where a new sheet should be unfolded.

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Maxson, Kans		2
Maxwell, N. Mex	63	11
Mayline, Kans		7
Medway, Kans	45	7
Melvern, Kans	21	2
Mineral Springs, N. Mex		15
Minneola, Cal		23
Mission, Kans		3
Monrovia, Cal	175	24
Moqui, Ariz	112	17
Morley, Colo	58	10
Morris, Kans		1
Morse, Colo		8
N.		
Navajo, Ariz	107	16
Nebo, Cal	161	23
Needles, Cal	145	21
Nelson, Ariz	135	20
Neosho Rapids, Kans	22	2
Nettleton, Kans		5
Neva, Kans		3
Nevin, Ariz	120	18
Newberry, Cal	160	23
Newton, Kans	25	3
Nickerson, Kans	31	4
Nolan, N. Mex		11
Noria, Kans		1
North Chaves, N. Mex		15
North Garcia, N. Mex		14
North Guam, N. Mex		15
North Pomona, Cal		24
Nueve, N. Mex		13
O.		
Offerle, Kans	35	5
Ojita, N. Mex	71	12
Olathe, Kans	20	1
Olivet, Kans	21	2
Omar, Kans	30	
Onava, N. Mex	68	12
Ono, Cal	169	24
Optimo, N. Mex	66	12
Ormega, Colo		9
Oro Grande, Cal	163	24
Ortiz, N. Mex	79	13
Osage, Kans	18	2
Otero, N. Mex	62	11
Ottawa Junction, Kans	20	1
P.		
Pan, Ariz		19
Paquita, N. Mex		14
Partridge, Kans	28	4
Pasadena, Cal	175	24
Pauline, Kans	15	2
Pawnee Rock, Kans	33	5
Paxton, Kans		4
Peabody, Kans	25	3
Peach Springs, Ariz	135	20
Penzance, Ariz		17
Perea, N. Mex	100	15
Peterton, Kans		2
Pica, Ariz	135	20
Pierceville, Kans	39	6
Pineveta, Ariz	133	19
Pinta, Ariz	107	16
Pisgah, Cal	158	23
Pitt, Ariz		19
Piute, Cal		22
Plevna, Kans		4
Plymouth, Kans		2
Pomona, Kans	21	2
Poso, Colo	54	10
Powell, Ariz	142	
Prowers, Colo	48	8
Q.		
Quenemo, Kans	21	2
Querino, Ariz		16
Quirk, N. Mex	94	14
Quivero, Ariz		19
R.		
Raton, N. Mex	61	10
Rayado, N. Mex	65	11
Raymond, Kans	31	4
Reading, Kans	19	2
Red Lake, Ariz		19
Rialto, Cal	172	24
Ribera, N. Mex	72	12
Richter, Kans		2
Ridgeton, Kans	21	2
Rio Puerco, N. Mex	91	14
Riordan, Ariz	120	18
Rito, N. Mex	93	14
Riverdale, Colo		9
Romero, N. Mex	70	12
Rosario, N. Mex	82	13
Rowe, N. Mex	73	13
Ruiz, N. Mex	85	13
S.		
Saffordville, Kans	22	2
St. John, Kans	30	5
Saltus, Cal	153	22
San Bernardino, Cal	169	24
San Dimas, Cal	174	24
Sanders, Ariz		16
Sandia, N. Mex	90	14
Sands, N. Mex	72	12
Santa Anita, Cal	175	24
Santa Fe, N. Mex	77	13
Schomberg, N. Mex		11
Scranton, Kans	17	2
Sears, Kans		6
Seligman, Ariz	134	19
Sereno, Ariz		19
Shoemaker, N. Mex	66	12
Siam, Cal	151	22
Siberia, Cal	156	22

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Simpson, Colo	53	10
Snow, Kans		1
South Garcia, N. Mex	91	14
South Guam, N. Mex	100	15
South Pasadena, Cal	175	
Spearville, Kans	35	6
Spencer, Kans		2
Spiess, N. Mex		13
Springer, N. Mex	64	11
Stafford, Kans	29	4
Starkville, Colo	58	10
Sterling, Kans	31	4
Strong City, Kans	23	3
Summit, Cal	166	24
Sulzbacher, N. Mex		12
Sunshine, Ariz	112	18
Supai, Ariz	131	19
Sutton, Kans	43	7
Suwanee, N. Mex	92	14
Sylvia, Kans		4
Symons, Colo	52	9
Syracuse, Kans	44	7

T.

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Tauy, Kans		1
Tecumseh, Kans	14	2
Thatcher, Colo	53	9
Thoreau, N. Mex	100	15
Thorn, Cal		24
Timpas, Colo	52	9
Todd, Cal	162	23
Toltec, N. Mex		15
Topeka, Kans	14	2
Topock, Ariz	143	21
Toril, N. Mex		11
Trinidad, Colo	55	10
Troy, Cal	159	23
Truxton, Ariz	136	20
Turner, Kans		1
Tyrone, Colo	54	10

U.

	Page.	Sheet.
Upland, Cal	173	24

V.

	Page.	Sheet.
Valentine, Ariz	137	20
Valle, Ariz		19
Verdemont, Cal	168	24
Victorville, Cal	164	24

W.

	Page.	Sheet.
Wade, Cal		24
Wagner, Kans		3
Wagon Mound, N. Mex	65	11
Wakarusa, Kans	16	2
Waldo, N. Mex	82	13
Walton, Kans		3
Watrous, N. Mex	67	12
Weaver, Kans		1
Wellsville, Kans	20	1
West, Colo	53	9
West Yard, N. Mex	104	16
Wettick, Kans		6
Whiteside, Kans		4
Wiggam, Kans		2
Wild, Cal	163	24
Wilder, Kans	9	1
Willaha, Ariz		19
Williams, Ariz	121	19
Wingate, N. Mex	101	15
Winona, Ariz	116	18
Winslow, Ariz	110	17
Wootton, Colo	59	10
Wright, Kans	35	6

Y.

	Page.	Sheet.
Yaggy, Kans		4
Yampai, Ariz	135	20
Yucca, Ariz	142	21

Z.

	Page.	Sheet.
Zarah, Kans		1
Zenith, Kans		4
Zuni, N. Mex	102	15

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